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BULLETIN

OF THE

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PRELIMINARY REPORT OF A COMMITTEE APPOINTED BY THE ADVISORY COMMISSION OF THE COUNCIL OF NATIONAL DEFENSE TO STUDY THE RELATION OF THE ENGINEERING SCHOOLS TO THE NATIONAL GOVERNMENT DURING THE PRESENT EMERGENCY.

The undersigned constitute a committee appointed by Dr. Hollis Godfrey of the Advisory Commission of the Council of National Defense as a committee to study the relation of the engineering schools to the national government during the present emergency.

The committee assembled in Washington on August 7 and remained in session until August 10. It re-assembled for two days on August 31.

The committee has consulted with the heads of the various bureaus, divisions and departments of the Department of War and the Department of the Navy as to the probable needs for scientifically and technically trained men in connection with the military operations. It has held conferences with representatives of the Shipping Board, of the Department of Labor, the Federal Board for Vocational Education and the Bureau of Education.

The committee respectfully recommended to the Honorable Secretary of War as follows:

''That an engineer familiar with the equipment and the capacity of the higher technical institutions of the country be commissioned in the Army and assigned the task of coordinating the needs of the Army for technically trained men with existing educational facilities.''

The committee's interview with the heads of divisions of the War Department showed that there were a few definite needs in the way of short course training which the technical schools of the country might meet at once. A typical problem was presented by the Signal Corps which desired technical instruction for six depot companies, one for each army department, each depot company consisting of one hundred and seventy-five enlisted men. The committee found an institution equipped and ready to furnish this training in each of the departments and made the preliminary arrangements for the signal corps.

The committee also recommended to the Honorable Secretary of War that students and alumni of technical institutions who are drafted into the national army be assigned to branches of the service for which their special technical training fits them. It undertook to secure for the secretary lists of such students and alumni thus far drafted into the national service. These lists are being compiled and will shortly be sent to the secretary's office.

At the request of the Secretary of the Navy, the committee has compiled a list of engineering schools whose graduates may be considered eligible for competitive examination for appointment as acting ensign in the Navy for the performance of engineering duty only, in accordance with an Act of Congress approved August 29, 1916.

Just prior to the second meeting of the committee on August 31, the Secretary of War assigned an officer of the General Staff to study the problem of bringing together the needs of the War Department for technically trained men and securing the coöperation of educational institutions of the country toward meeting these needs. The committee has held profitable conferences with this officer. It proposes to keep in touch with him and to lend its aid as far as may be desired in the solution of this problem. While undoubtedly the necessities of the war will make desirable material changes in the curricula of enginering schools, it is at the present impossible to foresee what those changes will be. The committee is not prepared to recommend any fundamental changes in courses of study at the present time as the result of its investigation. It is of the opinion, however, that certain military engineering subjects may profitably be introduced as soon as possible. The introduction of such subjects will tend to satisfy the patriotic enthusiasm of engineering students. Moreover, those students who later go into the army will find these subjects useful. The committee has in mind particularly the following: Military bridge building, the laying out and sanitation of camps, the making and reading of maps, rapid reconnaissance, the laying out of trenches, etc.

It suggests that engineering schools endeavor to secure the textbooks used by the army in these and other military subjects. Application may be made to the Book Department of the Army Service Schools, Ft. Leavenworth, Kansas, for a complete list of these textbooks. The titles of textbooks used at the ordnance proving grounds can probably be obtained from the commandant of the proving ground, Sandy Hook, New Jersey. The committee would recommend as especially valuable for the information of engineering school teachers "The Engineer in War," by Major P. S. Bond.

The committee plans to issue a complete report as soon as possible. Meanwhile, it would be glad to furnish on request any information of which it has come into possession as the result of its investigation thus far. Communications should be addressed to the Secretary of the Committee, Dr. S. P. Capen, 516 Munsey Building, Washington, D. C.

Respectfully submitted.

F. L. Bishop,
C. S. Howe,
M. S. Ketchum,
C. R. Mann,
S. P. Capen.

THE PREPARATION OF ENGINEERING STUDENTS FOR ARMY SERVICE.

BY HENRY B. DATES,

Professor of Electrical Engineering, Case School of Applied Science.

The great demand of the government for technically trained men, not only for civil life but for military work, has brought forcibly to the attention of the faculties of engineering colleges the question of the preparation of their students for military engineering service. Large numbers of students of the engineering colleges have enlisted in various branches of the service, some are in officers' training camps, and undoubtedly the future will see many of the men now in college in the service of the government.

It is difficult, in these days of intense preparation, to learn, through the usual channels of information, the character of the training needed by our students for army service. The military departments of the government are so overburdened with work that it is not possible for them to give the attention to requests for information that they would like to do and they would do in normal times.

In order to study the question at first hand Case School of Applied Science appointed a committee of its faculty to visit some of the army posts at which officers' schools are located, in order to study, at first hand, the work given at these schools and to determine what changes in the courses of study might profitably be made so that the graduates of the college might be more efficiently prepared for the army service without detracting from their training for efficient engineering work in civil life. The committee visited the Military Academy at West Point, the Ordnance School of Application at Sandy Hook Proving Grounds, the Engineering College at Washington

Barracks, the Coast Artillery School at Fort Monroe, and the Army Service Schools at Fort Leavenworth.

It is a surprise, to one who has not followed up closely the education work of the army, to find how many excellent schools for officers have been established. Necessarily, at present, the work of these schools is more or less suspended because of the great demand for officers for the troops, but considerable work is still being done in the schools and that of a most interesting character.

The officers of the various posts visited, though overburdened with multitudinous duties in connection with the training of new troops, were courteous to the extreme, placing every facility at the disposal of the committee to study the work of their schools and giving freely of their time to make us thoroughly acquainted with the details of their courses and of their methods of instruction.

One was immediately impressed with the high character of the work and the thoroughness of the instruction. The civilian colleges may well profit by a study of the organization of the schools, the soundness of their methods of instruction, the extreme care taken in the planning of the courses of study and the uniformly high character of the work done.

With the exception of the Military Academy at West Point army colleges are practically postgraduate institutions to which each year a limited number of officers are detailed for a year's course of study. While at the college the officer's entire time is given to the educational work and he has no military duties whatsoever. With this arrangement of time, an exceptionally earnest body of students and the aid of the military discipline, a perfectly surprising amount of work is accomplished.

While much of this work, as would be expected, is of a strictly military nature, a very considerable amount is similar to engineering courses given in many of our civilian engineering colleges.

The courses are, in general, characterized by a very large number of problems—many more than are usually given in our courses. The problems are excellently planned to emphasize fundamental principles and practical applications are continually made throughout the various courses. In fact, one is greatly impressed by the close association of theory with practice, on the principle that technical knowledge without the ability to apply the same is of questionable value. At most of the posts special buildings are provided for instructional purposes, the schools are manned by an enthusiastic body of officer instructors and well-equipped laboratories are provided.

The work of the Military Academy at West Point is more or less familiar to engineering teachers. It is interesting however to note, that here, as in other army schools, responsibility is placed directly on the students, not on the instructor; that emphasis is placed on the recitation, and that a student's standing is largely if not entirely dependent upon his daily work. The course of study includes mathematics, mechanics, chemistry, physics, elementary surveying, elementary electricity, elementary military engineering, together with other general subjects and much work of a military character. The engineering studies are not different in character and scope from those given in engineering colleges and it should be entirely practicable for colleges to give this work to all of their students.

The purpose of the Ordnance School of Application at Sandy Hook Proving Grounds is to train officers for the special work of the ordnance department such as the designing, testing, proving, and manufacturing of guns, explosives and ordnance material. Only commissioned officers who have had several years' service are detailed for this course and they are either graduates of West Point or of civilian engineering colleges. The course is two years in length—one spent in theoretical study at the Sandy Hook Proving Grounds and the following spent at the Watertown Arsenal, where instruction is given in shop work such as foundry, forging, machine tool work, and so forth, shop management, and strength of materials testing. The engineering work, as it touches the work of civilian colleges, comprises the chemistry of explosives, considerable work in electricity, and a small amount of steam engineering.

The Coast Artillery School at Fort Monroe in reality comprises two schools, one for Coast Artillery Officers and one for selected enlisted men. As stated in the annual report of the commandant the school has these objects in view:

(*a*) ''To give all Coast Artillery Officers a year's systematic training in the technical duties of their profession—theoretical to cover the entire field, practical to cover the equipment supplied.''

(*b*) ''To educate and train specially selected enlisted men for the higher grades in the Coast Artillery non-commissioned staff.''

The engineering work in the Officers' Division includes a course in electrical engineering, a short course in steam engineering, a course in submarine mining, which includes the applications of electricity to the art and work of civil engineering. Because of the very extensive applications of electricity in the Coast Artillery work much time is given to the course in electrical engineering. Some of the electrical subjects on which special emphasis is laid are switchboard and power distribution, testing cables and installations, fire control apparatus, installation and maintenance of submarine fire control cables, searchlight construction and operation and radio engineering. The tendency at this school is to still further expand the work in electrical engineering, to curtail the work in steam engineering and concentrate the mechanical engineering largely on the care and operation of oil and gas engines. To this end the course in internal combustion engines has been enlarged to include automobile engines, automobile equipment with the gradual abandonment of the work in steam. The courses of the school are most excellently arranged, the electrical laboratories are splendidly eqiupped and the standard is very high and compares favorably with that of the best engineering colleges. The course does not take up the design of the electrical apparatus but gives a very thorough review of fundamentals and places great emphasis upon the applications of electricity in the Coast Defense Service.

The work in the enlisted men's division is divided into four courses: the artillery course, the electrical course, the clerical course and the radio course, all of which are of one year's duration except the radio course, which is finished in six months. The work of the enlisted men's school was of great interest, for though probably the larger part of the students had not had the equivalent of a high-school course much of the work that they were doing was fully equal to that of the first two years of college. Of course special emphasis is put upon the maintenance and operation of the apparatus and the applications to the special problems of the coast defense work, but a surprisingly large amount of theory is given and the fine results obtained are a splendid example of what can be done with a selected group of men under ideal conditions, splendidly planned courses of study, and intensified application.

Several distinct courses of study were found at the engineers' school for officers at Fort Leavenworth, Kansas. Some of these courses were distinctly military in character but in the department of engineering was found a very large amount of civil-engineering work applied to military requirements. In the army signal school at this post, splendid work is given in direct- and alternating-current machinery, storage batteries, telephone and telegraph lines as related to military service, radio telegraphy, and a general course in electrical engineering.

In general the army schools visited are splendidly organized and do work of the best character. Their courses of study are well planned and their methods of instruction such as civilian colleges may well build on to advantage. The efficiency of these schools is greatly aided by the military discipline and by the small sections handled—about ten men per section—but the instruction is of the very highest character and one cannot but be impressed with the thoroughness of the courses and methods and by the results obtained. In the engineering work that is similar to that of the civilian colleges the daily recitation method is in use and little stress is laid on lectures.

The technical institutions of the country might profitably introduce into their courses of study work which will be of immediate value to the men in the army and which will at the same time be of value in civilian life. Many of our colleges already give to most of their students courses in elementary and topographical surveying and in electrical engineering.

If the elementary work in surveying were given in the freshman year, this course could be followed up in succeeding years by military sketching of the character given in the army schools, map reading and map problems, military bridges, practice in tying knots and lashings and a study of trench layouts. Field practice could be given in laying out trenches and in the erection of military bridges. It would seem desirable in the erection of bridges that the class should be handled as a military unit and the erection carried out with military dispatch, the speed to be emphasized and developed by competition between sections.

As regards electrical engineering, a year's course in direct- and alternating-current machinery is now given to many students in the junior year. This course could be readily planned to emphasize the distribution of power and the applications of electrical apparatus, and to include the elements of cable work and testing, searchlights, the principles of the telephone and telegraph and the application of other devices most commonly met with in army service.

Further expansion of the work could be made by giving a series of short courses in the senior year. The problems for the work of all courses should be drawn from army as well as from civilian practice. Laboratory work should be made an important part of the course. The students should also have a course in internal combustion engines.

It would seem advisable for all students, irrespective of the particular branch of engineering in which they intend to specialize, to have both the civil and electrical engineering work.

It is very probable that we shall see in the future many graduates of civilian colleges taking up the army service for a career and it is believed that the engineering colleges will find by a careful study of the problem, that changes can be made in their present courses of study which, without decreasing the efficiency of the training for civilian engineering, will better fit their students for the problems of the army service.

COOPERATIVE PLAN OF ENGINEERING EDUCATION.

BY J. W. W. HALLOCK,

Director, Coöperative Work, University of Pittsburgh.

The school of engineering of the University of Pittsburgh is endeavoring to train men capable of filling executive positions in engineering industries. To accomplish this aim requires that each student shall receive a maximum amount of practical experience in the branches of the industries for which he displays the greatest aptitude and liking. It requires further that he shall have a broad perspective of engineering work and a working knowledge of the principles of industrial management, shop organization, plant layout, etc., as well as thorough knowledge of engineering. Situated as it is in the greatest industrial center of the world, the University of Pittsburgh is in the best possible position to assist in the training of such men. The demand for men possessing such training cannot be questioned and it remains for us to give to engineering students, preferably during their college course, the broad experience and breadth of view necessary in executive work. It is desired to herein describe the plan which has been a great factor in accomplishing this aim at the University of Pittsburgh, namely the coöperative plan of engineering education.

Briefly the operation of the plan is as follows.

The freshman and senior years are spent entirely in classroom and laboratory work. The sophomore and junior years, which are divided into three month terms, are spent alternating between classroom and the shop. At the close of the freshman year the class is divided into two equal sections; one of these sections remains in school for the summer term;

the second section is assigned to coöperative work for the summer term. In the fall term the section that has been on coöperative work returns to school and the positions thus vacated are filled by assignments from the section remaining in school. The two sections alternate regularly every three months until the beginning of the senior year with the exception that all students are required to be in school during the summer ending the sophomore year. The following diagram will illustrate this arrangement.

One fact to be noted here is that all students in engineering in the University of Pittsburgh are required to do coöperative work. Thus any students having the desire to secure an engineering education with a minimum of personal effort are automatically excluded.

The arrangement of three month periods spent alternately in school and on coöperative work is ideal for a four-term plan. Beginning with the fall term the alternations fall approximately in the Christmas and spring vacations and at the beginning of the usual summer vacation. This is an excellent time to make the necessary changes in the shop positions. The firms offering coöperation with the school are practically unanimous in the opinion that the three-month period spent in the shop is the most efficient from their standpoint, as it permits them to arrange a larger variety of work for each engineering student without any sacrifice in the usefulness of such services to the firm. It also enables the employer to have a longer continuous period over which to observe the fitness of any one student for the work in hand. Incidentally the number of terms of work to be repeated in the classroom and laboratory is kept at a minimum. As will be observed from the above diagram it is necessary to repeat only four terms, one year of repeated work in four years. The amount of theory given in any course is not reduced by having five terms instead of six during the sophomore and junior years, as the five terms spent in school contain the same required amount of work as is originally contained in two full years.

The freshman year which is spent entirely in classroom and laboratory work permits a close study of the individual student before any definite assignment is made to coöperative work. The director of coöperative work, who is also freshman advisor and instructor in elementary shop work, is in constant and intimate contact with every member of the freshman class. This permits a careful study of the fitness of each student for engineering work. Too often a student is led to taking up engineering work by the misguided advice of family or friends without due regard to his aptness or liking for such work. Many students whose efforts are thus misguided are frequently guided into a more congenial line of work, resulting ultimately in more substantial and rapid advancement to them.

During the freshman year, the subjects taken by all engineering students are identical. Near the close of the year, lectures are delivered by the heads of the different departments and by outside speakers, the object of these lectures being to familiarize the student with the usual scope of work in any of the branches of the profession. Guided by these lectures and by the director of coöperative work, each student makes a selection of the branch of engineering he elects to follow. By this time, the director has a fairly comprehensive set of notes on the general characteristics of every freshman. The conclusions reached are carefully checked with similar estimates from all freshman instructors and the heads of the departments in which such students have worked. Any discrepancies or wide variations in estimate are again checked to make the records as accurate as possible. As an aid to making these estimates the following form was devised:

Each freshman is required to fill out one of these forms. Knowing the amount of time ordinarily required for the preparation and attendance on classroom and laboratory work, a close estimate of the time available for recreation may be made. The statements of how a student spends this spare time give a fair indication of each student's earnestness of purpose in securing his professional training. For example, one student indicated on the above form that he attended a theater ''at least three afternoons a week.'' From this student's schedule, it was seen that only two afternoons were available each week. Investigation showed a systematic failure to attend classes on one or more afternoons. In this case, calling such neglect to the student's attention did not produce the desired result and a failure in the first semester's work was the natural consequence.

From the very beginning of a student's course, a study is made of the phase of engineering work to which he seems best adapted; that is, whether operating, manufacturing or designing. The classroom readily lends itself to such a study if classes are small, but the practical coöperative work greatly facilitates it. In this, also, the coöperating firms have rendered valuable aid, both in assisting in such study and in changing the student's work to fit his growth in it. It must not be thought, however, that a student's work is changed at every expression of dislike or dissatisfaction. In cases where objection is made to the character of the work, the stduent is led to see the importance of a familiarity with the work in hand and with the work that may be observed going on about him. No effort is made to fit each student to the particular job assigned. The job is rather used as a means of familiarizing the student with that particular phase of engineering work, and he is constantly being shown the relation of that particular work to the whole plant in question.

With proper coöperation, therefore, the plan may be the means of the more rapidly and easily leading the student into congenial and profitable work.

It may be argued that the study mentioned above leads to unwarranted specialization at a time when general facts only should be observed. It will be noted, however, that the divisions mentioned, operating, manufacturing and designing, are very general. Only in very special cases is such a study permitted to become highly specialized. A student who displays a marked interest in operating work may be assigned for his first term to a power plant. Here his work may be as helper to the switchboard attendant. When visited by the director of coöperative work, points of interest regarding coal and ash handling apparatus, boiler settings, methods of cleaning, etc., are observed and discussed. During later terms, the question of power-plant economies, steam consumption, power costs, etc., may be taken up intelligently and profitably. All of the coöperating firms urge the students to ask questions, take notes and make sketches. Similarly students in each of the other lines indicated are led to look into all departments and to see the relation of each to the other.

Soon after a student is assigned to coöperative work he is furnished an outline of general points of interest to be observed. These outlines are prepared by the director of coöperative work with the assistance and suggestions of officials of coöperating firms. Outlines for first terms of work are necessarily rather general, as the student has had no real engineering theory. During later work, however, these outlines may be made more specific and the points indicated are usually a little in advance of the theory the student has had. Thus he is led to anticipate the principal points of the theory. An example of a very general outline is given on page —. It may easily be seen how such an outline may be enlarged and developed.

A. Location and territory served.
B. Organization of executive force.
C. Details of plant layout and operation.
    1. Coal and ash handling apparatus.
        (*a*) Type.
        (*b*) Power consumed.
        (*c*) Efficiency in operation.
    2. Stockers.
        (*a*) Type and make.
        (*b*) Method of driving.

    - (*c*) Regulation of speed.
    - (*d*) Requirements as to grade of fuel.
  - 3. Boilers.
    - (*a*) Arrangement in plant.
    - (*b*) Type and horse-power.
    - (*c*) Method of cleaning.
    - (*d*) Arrangement of baffles.
    - (*e*) Average evaporation per pound of fuel.
  - 4. Engines.
    - (*a*) Condensing or non-condensing.
    - (*b*) Size of power.
    - (*c*) Types of valves and governing.
  - 5. Generators.
  - 6. Switchboards.
    - (*a*) Generator panels.
    - (*b*) Distributing panels.
- *D*. Observations on conditions conducive to health of employees.
  - 1. Heating and ventilation.
  - 2. Illumination.
  - 3. Toilet facilities.
- *E*. Observation on skilled and unskilled labor employed.
  - 1. Comparison of American and Foreign
    - (*a*) Religious and social views.
    - (*b*) Attitude toward work, etc.
  - 2. Capacity for development in the work.

During a student's employment on coöperative work, he is considered an employee of the firm and as such observes shop hours, receives regular wages, and is subject to all the restrictions and privileges of the men with whom he is working. The wages paid coöperative students varies with the nature of the work and with the degree of advancement of the student in his course. On some of the railroad work, the rate of pay is as low as 18 cents per hour, while for some of the more advanced work it is 30 cents. It is to be noted that these figures compare favorably with those applying on graduate engineer apprentice courses. It is customary for a student to receive about $450 in wages during his entire coöperative work. This offers a distinct money advantage to students taking engineering courses under the coöperative plan. As indicated above the director of coöperative work visits each student at regular intervals. Usually from an hour to two hours is spent with each student, depending on the nature of his work and the amount of interruption advisable. The outlines discussed above form an excellent basis for discussion and questioning. Opportunity is also afforded for still further study of the plant by the director, and for discussion of the progress of the student and the work with foremen and superintendents. The visits by the director are supplemented by bi-weekly reports in person to the university. Here are discussed in the presence of other students the special interest regarding each job. All the students from any one department thereby profit by this interchange of ideas.

At the close of each term of coöperative work, the student is required to submit a written report covering the work done. These reports must be satisfactory before credit is allowed for the work.* Reports are also received from foremen and superintendents under whom the student has worked. These reports are brief, but form a good basis on which to arrange future work and serve as a fair estimate of a student's development in the work. The following is the form of report:

UNIVERSITY OF PITTSBURGH.

REPORT ON COÖPERATIVE STUDENT.

Name ....
Check No. ....Department..............................
Date student began work ....
Date left ....

---

* Frequently they contain original observations or suggestions for the improvement of the work and when brought to the attention of the officials of the firm their adoption follows.

No. days actually worked ....
Please rate on the following: ....
Ability .... Reliability..................
Industry .... Initiative....................
Tact ....
(Rate as "Good," "Average," or "Poor.")
Remarks: ....
....
....
Sign here ....
Position ....
Date ....

While progress in arranging coöperative positions for students was at first slow, the list of firms offering to employ students shows a tendency to grow faster than the supply of men. The following list of firms will give an indication of the variety of work offered:

Duquesne Steel Foundry.
Duquesne Steel Works.
Douglass & McKnight, Civil Engineers.
John F. Casey Contracting Co.
Farris Engineering Co.
Hope Engineering and Supply Co.
Lewis Foundry & Machine Co.
Mesta Machine Co.
McClintic-Marshall Construction Co.
National Tube Co.
Pennsylvania Railroad Co.
Pittsburgh Steel Co.
Pittsburgh Transformer Co.
Pennsylvania State Dept. of Health.
Oliver Power Plant.
H. K. Porter Plant.
Riter-Conley Mfg. Co.
Pressed Steel Car Co.
Union Switch & Signal Co.
United States Engineers Office.
Westinghouse Electric & Mfg. Co.
Carnegie Institute and Library.
National Malleable Steel Castings Co.
Pittsburgh Railways Co.
Republic Chemical Co.
Atlantic Refining Co.
Bessemer & Lake Erie R. R.
Duquesne Light Co.
Pittsburgh & Lake Erie R. R.
Bell Telephone Co.
Pittsburgh Valve Foundry & Construction Co.
Collins, Gordon Contracting Co.
Pittsburgh Construction Co.
A. M. Byers Co.
Fort Pitt Bridge Works.
Pittsburgh Coal Co.
American Bridge Co.
Aluminum Company of America.
Harrop, Hopkins & Taylor.
H. Koppers Co.
W. G. Wilkins Co.
Pennsylvania State Highway Dept.
Allegheny County Engineer.

City of Pittsburgh, Bureau of Engineering.
City of Pittsburgh, Dept. of Public Health.
General Electric Company.
R. W. Hunt & Co.
Blum, Weldin & Co.

One of the objections which the coöperative plan was designed to overcome is the increasing tendency to require engineering graduates to serve a special apprenticeship before entering the engineering department or being absorbed into the executive work. The establishment of such apprentice courses, while not necessarily signifying any lack of training in the essentials of engineering theory, at least implies the necessity for practical training. If then, as is frequently the case, a student is preparing for work with some certain firm, it may be possible to adapt the coöperative plan to such apprentice courses. At the University of Pittsburgh this is the case. For instance, students planning to enter the engineering apprentice course at the Westinghouse Electric & Manufacturing Company may enter the course at the beginning of their third coöperative term, thus securing six full months credit on the course before their graduation from the university. The Pittsburgh Railways Company offers the same opportunity to students of the university. The fact that these companies continue the arrangement, and the employment of such students after graduation is another testimonial of the success of the plan.

With some firms, the importance of having a systematic plan of advancing the students through the plant is not apparent. In such cases, the suggestion of a plan by the director of coöperative work leads to the adoption of a regular and progressive plan. In other cases, such as the shops of the Pittsburgh Railways Company above mentioned, as well-organized routine already exists. In the case of the railways company, each of the following departments is served:

Repairing
Winding
Wiring
Motor and truck
Machine
Drafting
Stoves
Operating (or barns)

Transfer from one department to another is affected by the railways company officials, but it is customary for undergraduate students to serve one whole term in each of the above departments. In this case it is impossible to complete the cycle of departments during the university course. Work is done in each of the other mentioned departments after graduation, however, and the practical work preparatory to engineering or executive work is the sooner completed.

Many instances might be cited to illustrate the development of students by reason of the practical experience obtained on coöperative work. For instance, one student was recently placed with the Lewis Foundry and Machine Co., manufacturers of rolling-mill machinery. His work was in the metallurgists' laboratory and consisted in the analysis of samples of cast iron, coal, slag, etc. He displayed such an interest in the work and made so many investigations of the physical differences of the various grades of the product that his research—done on his own time—was the basis of many improvements at the plant. To-day he is a near-authority on the metallurgy of iron and steel. Another student, engaged with a Pittsburgh machinery company, devised a special chuck for lathe use and an ingenious centering device for lathe work—two thing which have since resulted in enormous savings to the firm by whom he was employed. These two students will unquestionably be sought after graduation.

On the other hand, of course, many instances might be quoted showing the failure of students to grasp the opportunity offered by the coöperative plan and the distaste for the kind of work given. One student engaged on the fabrication of structural steel shapes telephoned the director of cooperative work (after having been on the work two weeks) that the work was hard and dirty and that the rest of his gang were foreigners and he couldn't understand them. He was advised that any engineering work was hard, that soap is cheap, that he had an excellent chance to study an additional modern language, and that if he was not gang leader in one month he need not return to school. The result was that he completed the term with credit to himself and the work and is today one of the best all-round engineering students. Another student was indignant on being told that his work was not satisfactory as he said he had been ''on the job every day.'' He failed to see the value of the practical work, and displayed so fiery a temper that an interview with his father was necessary. The interview showed that he had none of his father's temper, as none of the latter's seemed to be missing. However, the father was convinced of the advisability of his son's taking a broader view of the work. At this writing it is too early to predict the outcome of this case, but it is altogether possible that this student may yet develop into a master engineer.

About two years ago, a coöperative student was employed by a bridge company on field work. During his last term he was in charge of the construction of a bridge in West Virginia. During his senior year he was employed by the company in all of his spare time. Before commencement he was sent by them to a new job, which he was expected to carry out after graduation. His services were considered so valuable that he was allowed only half a day from his work to attend the commencement exercises and receive his diploma.

The coöperative plan of engineering education has been in effect at the University of Pittsburgh for almost seven years. In order to ascertain the attitude of alumni toward the plan, questionnaires were recently addressed to them. Replies were received from seventy per cent. of those addressed. The attitude of these men may therefore be taken as representative. The following were the questions asked:

1. Did the experience you obtained in the coöperative work apply directly on the work you took up after graduation?

2*a*. Do you feel that your first position after graduation was a more responsible one than you might have obtained without coöperative work?

2*b*. Have you ever been informed as to this point by any other man under whom or with whom you have worked?

3*a*. Was the salary on your first position after graduation higher than it would have been without your coöperative experience?

3*b*. Have you ever been so informed by any official of the firm?

4. Does your advancement along engineering lines seem more or less rapid and substantial than other engineers in the same company who did not receive coöperative work?

Question Number	Per Cent. Answered Yes	Per Cent. Answered No	Per Cent. Noncommital	Per Cent. Not Replying
1	76.5	21	2.5	0
2*a*	47	48	5	0
2*b*	28	67	0	5
b3*a*	50	50	0	0
3*b*	19	76	0	5
4	55	8	37	

It is interesting to note that more than two thirds of these alumni accepted positions after graduation in the line of work followed on the major part of their coöperative work. This is due to the fact that many graduates are naturally employed by the same firms who employed them on coöperative work.

Only about half of these men considered their work immediately after graduation to be more responsible than it would have been without coöperative work. This is no doubt due to the fact that the men grow in capacity for such work and, therefore, feel that they are capable of assuming greater responsibility. It is natural that the percentages of replies to questions 2*a* and 3*a* should be about the same, the increased salary being due to the added responsibility.

The disadvantages of the coöperative plan are few but apparent. First, the employment of the plan necessitates a certain amount of repeated classroom and laboratory work. The

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[*] Of the men who did not commit themselves one way or the other all but 4.5 per cent. explained that they had been out of school too short a time to make observations on this point.

extent of this repetition depends largely on the length of alternating periods on coöperative work and in school. The three-months term seems to lend itself to greater flexibility and permits a student to complete any one subject before leaving the classroom for the shop. Second, the executive details when such a plan is in force are more difficult. Third, a student's steady progress in theory may be said to be somewhat interrupted, but these interruptions are less serious in three-months periods than in shorter periods. Finelly, there is always the danger that a depression in business will result in the discontinuance of coöperation by some firms.

It is believed that these disadvantages are more than offset by the immense advantages and great opportunities set forth above. Summing up, the advantages might be stated as these:

1. In the usual engineering courses the objection is frequently made that a student receives no real engineering work until his junior or senior year.

NOTES ON THE TEACHING OF SINGLE-STROKE FREEHAND LETTERING.

BY RICHARD S. KIRBY,

Assistant Professor of Drawing and Descriptive Geometry, Sheffield Scientific School, Yale University.

Since the introduction of Reinhardt's system, in 1895, the importance of the systematic teaching of single-stroke freehand lettering as an integral part of a course in mechanical drawing has gradually come to be generally appreciated. The five most widely used texts on mechanical drawing published during the past half-dozen years devote on an average 21 pages each, or ten per cent. of their space, to freehand lettering; of these books, one devotes only 4 pages out of 141—another 50 out of 277.

The following observations on the teaching of single-stroke lettering to engineering students are the result of the author's experience with beginners, both in classroom and drafting room.

1. Lettering should be taught as such—the art cannot be unconsciously absorbed overnight.

2. A student is interested in a subject in which his advance in proficiency can readily be shown him.

3. Lettering drill should be administered in homeopathic doses repeated at frequent intervals; a long assignment is tiring to the hand, the eye and the mind.

4. For a novice to attempt lettering practice without the use of top and bottom guide lines and slope lines is largely time wasted.

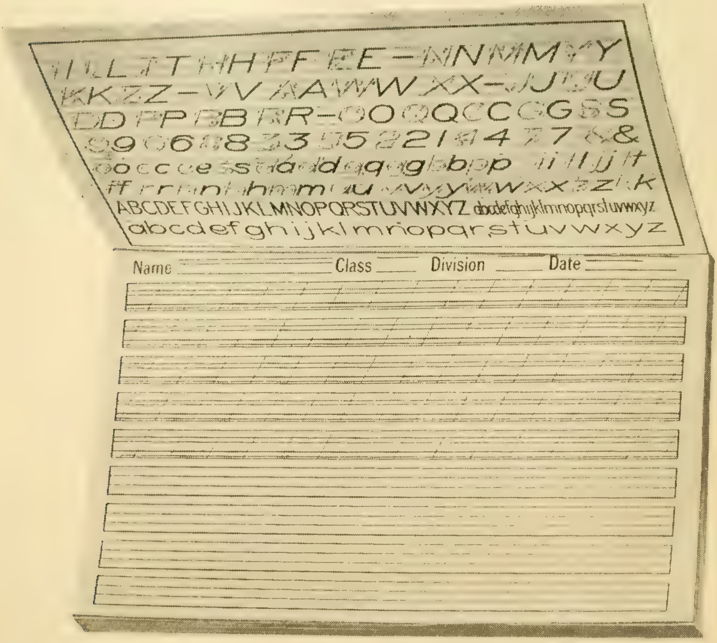
5. Inclined letters are formed more naturally than vertical letters and should therefore be taken up first.

6. Pencil work should precede that with pen and ink, and

should be continued until both the form of each letter and the order and direction of its strokes have been mastered.

7. The letters should be studied in family groups, each drill period prefaced by a discussion of the points of resemblance and dissimilarity between the letters of the group.

8. The spacing of single letters should at first be treated as of no consequence; only after thorough drill on the separate letters should they be grouped into words and finally into sentences.


ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
abcdefghijklmnopqrstuvwxyz
Name
Class
Division
Date

9. The most effective personal criticism is that given during the lettering period, before the work has grown cold.

In his endeavor to simplify the teaching of lettering the author has evolved the little tablet shown in the accompanying illustration. The tablet is designed to save time which the student otherwise would spend in ruling guide lines. Moreover, his copy must perforce be within a few inches of the letters he is attempting to execute. Certain advantages accrue to the instructor as well, such as elasticity of system, and convenience in checking and filing.

The tablet is 5 inches by 8 inches, with the longer dimension horizontal, and it is bound at the top. It contains 30 sheets of heavy ledger paper stiff enough to file vertically—each sheet ruled, in yellow, for 9 rows of letters. Horizontal guide lines provide for several heights of letters, and slope lines (at 63½ degrees, or 1 to 2) are drawn for the first 5 rows. There is a heavy manila cover, on the inside of which is printed, in black, a capital and a lower case alphabet of single-stroke letters, with the sequence and direction of the strokes noted; also several alphabets of vertical letters.

At the Sheffield Scientific School, 8 to 10 hours during freshman year are devoted by the average engineering student to single-stroke freehand lettering. Drill is provided for at weekly intervals throughout the year, using the first twenty minutes of one drawing period out of three. A series of about 25 progressive exercises is scheduled for the year, beginning with Exercise No. 1, which is a study of the lower-case letters o, c, e and s. Review exercises are inserted at suitable intervals. The last 8 exercises consist each of a group of words or phrases peculiar to the vocabulary of a single engineering field.

Mimeographed slips are used in prescribing the letters or words which constitute a day's assignment, with the size of the letters. The cards are collected after each day's work, and are filed in such way as to exhibit the progress of each student for the entire term almost at a glance. This system reduces the routine work of the instructor with a large class to a minimum and enables him to concentrate his attention on the business of constructive criticism of the work of his students.

EDUCATION VERSUS ENGINEERING.

BY ABRAHAM PRESS,

Assistant Professor of Electrical Engineering, University of Oklahoma.

The first impulse would be to deny that there could be anything antithetical in the desires of educators and the employing engineers. As a matter of fact the ideal of the employer is to obtain the best professional service for the least monetary outlay. It is difficult to believe that the hard headed business man can see any monetary worth in ''cultural'' proclivities. True, that engineering employers know that what is called ''breadth'' in the outlook on life is necessary for the executive side of an engineering undertaking. Here however the important feature is that indefinable something that has an almost machiavellian characteristic. Some may call it tact, others perhaps the skill to hoodwink an unsophisticated subordinate. One thing is certain, it does not represent what educators imply by the broad cultural outlook on life.

The ideal of the educator, it is safe to say, is in developing a proficient engineer also versed in the humanities. Some of these humanities are very often of such a nature as to ''unsettle'' the minds of the underpaid technician. Already there is considerable social unrest. To train a would-be analytical mind so that he should be in a position to appreciate the modern problem drama, or develop a taste for the new emotional tendencies in art, would not represent efficiency from a works standpoint without our employers also being willing to acquire education along these lines. If, on the other hand, it is thought that such material can be made to be satisfied with humanities along purely classical lines, then the results both as to technics and the humanities must remain as they are in fact to-day. It would be better to entirely divorce the two.

However, it is not enough to teach dry technics without at the same time inculcating a spirit of cultural devotion to an ideal. To hold forth to the student the one single thought that he is to study engineering because ''it pays'' is to be false to the ideal of every true educator. To hold freshmen conferences in which the heads of the engineering departments vie with the arts and science departments, and with each other, in misrepresenting the wonderful money-making possibilities of their professions is a scandal nauseating to the highest degree.

Curricula based on the money ideal alone cannot turn out engineers capable of holding their own in the world's commerce. Competition to get large attendances strikes at the very foundation of the national life. It makes for poor earlier training, and what is worse, poor scholarship leading to the degrees. Indeed the evil is so great that about the worst thing a real student can do is to attend almost any of the technical schools—certainly any of the newer ones in which it is professedly the purpose to obtain a record as to numbers.

There is also a short-sighted policy from a national standpoint which the English engineering firms are beginning to take to heart. It is that poor wages make for disinterestedness and lack of scholarship in those doomed to work at less than artisan's wages. It reflects in very much the same way in the teaching profession, since, as Dr. Drysdale confessed, the higher positions were invariably filled and held by those individuals whose mental make up was directed to worming their way as early as possible into the higher positions of executiveness rather than to those of scholarship.

It would appear to be futile to discuss promoting engineering education when a man's scholarship is about the last thing thought of as fitting him for his position. As one president of a university admitted, he was not interested as to how much time or scholarship was devoted to the work of the classes to be held, as he was that first, the students should be made to believe that they were ''getting by with it,'' and secondly, that the teacher was able "to get away with it." What madness it is to talk of scholarship under such conditions. To whom shall one appeal when presidents talk like the above and deans obtain their posts by pure seniority, even when incapable of talking a very simple English, or when engineering instructors and professors without engineering experience are selected for cheapness and youthfulness.

Surely a committee of the Society for the Promotion of Engineering Education ought to be formed where complaints of the above type can be lodged with the understanding that if authenticated such conditions should be "hall-marked," so that the engineering industries of the country shall not suffer and the schools in good standing profit thereby.

It is notorious that many real students begin their real education only after leaving school. The mathematics, physics and chemistry are very often of the most slipshod and unrelated character. Only that type of student can make good culturally when left free to choose the electives that dire necessity after school has taught him are most important. It is difficult to see how mathematics can be taught properly at the technical schools when there is no attempt of choosing mathematical teachers for their engineering experience. Where are the advertisements to this effect? It is difficult to turn out properly trained engineers when the teachers of physics and of chemistry are not expected to have had actual engineering experience. Where are the advertisements to this effect, and what effort is made to draw such prospective teachers away from industry?

As a matter of fact till the time arrives when the appointments and the promotions in our engineering colleges will be made strictly on a basis of actual engineering experience, published research, as well as "getting by with it" with the student body, there is little hope for the avoidance of such cataclysms as we are now witnessing—at least such is the opinion of educators to-day in Great Britain and has been the opinion of the writer for the last fifteen years.

CLASSROOM ADMINISTRATION.

BY M. L. FISHER,

Professor of Crop Production and Farm Management, Purdue University.

The instructor who goes into a classroom has two functions to perform: first, to impart information; second, to maintain discipline. In college classes the second ought to be of minor consequence. However, it frequently happens that college classes are much in need of discipline.

Information is imparted in three general ways: first, by lecture; second, by means of textbooks and quizzing; and third, by demonstrations. The giving of instruction by lecturing is one of the most common methods in colleges and universities. It cannot be said that this method is entirely popular with students; many men who have ability are poor lecturers. When lectures are given, for which students are to be held responsible for the information imparted, time should be given for jotting down the important statements. The statements should be concise, brief, and to the point, and these should be followed by elucidation of the facts or principles involved. It is not desirable to give undergraduate students lectures in which note-taking is not required, for they have not reached sufficient maturity to appreciate the value of the material. Also, the act of note-taking impresses the fact upon the minds of the students. The use of a textbook is probably the best method of imparting instruction along those lines of work where the principles and facts have been pretty well worked out. Where students are required to purchase a text, the text should be thoroughly studied and mastered. To require students to purchase a text and then continue lecturing on the subject matter of the text is equivalent to the instructor saying that he can present the subject matter in clearer form than the author has written it, and that the students have been required to buy the textbook in order to compliment its author. The first condition is one that the instructor ought not to admit, and the second is not worthy of him. Having required the student to purchase a text he should be held responsible for its contents, both in oral and written quizzes. These quizzes should be rigid and exact. Questions asked should be such as to require the student to give definite, concise statements. Students need to practice more than they do the expression of their knowledge in exact statements. Some phases of instruction are best given by means of demonstrations. When this is done all details of the operation should be visible to the student and it is a rare class in which every member will get the same idea from one performance of a demonstration. The repetition of a demonstration serves to clear up doubtful points in the minds of the various members of the class; in some cases several repetitions are needed. A great deal of the effectiveness of a demonstration depends upon the ability of the instructor to express himself clearly and definitely.

The preparation of the instructor is largely responsible for the success of his work. The instructor should master the subject matter so that he can go before his class and not be confined to his notes or text. If he is giving lectures he should be able to stand out in front of his class and present the facts and principles of a subject in an offhand manner. It is helpful to the student if the instructor outlines his lecture on the blackboard as he proceeds. The lecture should be so arranged and organized that it proceeds logically in all of its parts. In quizzing a class the instructor should be able to ask his questions in a running-fire method and not have to refer to the text to find out what the next question is to be; he should have determined beforehand the principal questions to be asked on the assignment. Out of the answers will grow a great many other questions to be asked on the spur of the moment. Students should be required to give clear, intelligible answers or explanations. The instructor should insist on clearness and conciseness of statements.

Among the items of discipline that we have to consider are punctuality, decorum, and attitude. Among college students punctuality is one of the big problems. Instructors secure this in different ways; some have penalties for tardiness or absence; others secure punctuality by showing the student the importance of the habits of punctuality and regularity. Students who are habitually late to class and irregular in their attendance are likely to conduct their own business affairs in the same way and such habits carried into employment cause the individual soon to lose his place.

The instructor is largely responsible for the decorum of a classroom. He must himself be calm and self-possessed. Any nervousness on his part is contagious. A fidgety or noisy instructor has the same kind of a class. Some instructors in lecturing address their classes in a voice loud enough to attract the attention of a campmeeting. The tidiness and orderly arrangement of a room has much to do with good deportment on the part of the pupils. A room strewn with scraps of paper, and chairs out of line does not induce orderly habits on the part of students. If each student is assigned a particular seat, pushing and crowding for the best seats will be obviated. The instructor should call attention to boisterous conduct on the part of his pupils. They should understand that rowdyism is entirely out of place within college walls.

The efficiency of the instructor is greatly affected by the attitude of the student. The student who lounges in his seat is likely to be sluggish and careless in his thought. He is not likely to think clearly or accurately. When called upon to recite he should stand erect and speak in a proper tone of voice, distinctly and concisely. Accurate expression should be sought for on the part of the instructor. Undue levity between instructor and student in the classroom is not desirable. However, no instructor should assume a superior air in the presence of his pupils. A natural, normal manner before a class puts them at ease and obtains the best response they are capable of giving. An instructor should place confidence in the honesty of his students. Suspiciousness on the part of the instructor is always rewarded by cheating on the part of the students. The instructor should seek to have his students realize that cribbing is a crime. A student who does crooked work in the classroom will not be above doing dishonest things in the business world, if the situation seems to demand it.

Perhaps no branch of educational work is so little supervised as that done in colleges. The different schools and departments should be closely supervised by the president of the institution. Heads of departments and divisions should see that the work of their assistants is carefully and properly done. The young instructor should have sympathetic advice and direction by his division head. Many young instructors fail in their work because they have not been properly placed, or advised, in their work. The heads of the departments should see that various courses are well coördinated and articulated. Each course of instruction should connect with the courses which have gone before and those which are to come. For many students the bridging of the gulf between the high school and the freshman work in college is more than they can accomplish and the result is failure in their freshman work. It is the duty of the heads of schools, deans, and president to provide proper facilities for instruction and to see that these facilities are used. Careful choice should be made of instructors and there should be frequent consulting and advising with those in charge of distinct lines of work. Deans and the president ought to get in close contact with individual instructors, see that all are carefully related to each other and that the work goes forward without a hitch or a break.

DO THE NATIONAL ENGINEERING SOCIETIES DISCREDIT ENGINEERING EDUCATION?

BY J. R. BENTON,

Dean, College of Engineering, University of Florida.

Of course the answer is ''No.'' Yet there are some particulars (the discussion of which forms the purpose of this note) which might seem to call for an affirmative answer if they formed the whole evidence on this question.

The national engineering societies admit to membership only such persons as have had professional experience of specified amount. They have no educational requirements as such. For admission the only recognition they give to technical education is as a substitute for a certain amount of practical experience. As such they do not seem to rate technical education very highly. The American Society of Civil Engineers in its constitution (Article II, Section 2) specifies that ''*graduation* from a school of engineering of recognized reputation shall be considered as equivalent to *two years active practise.*'' The American Institute of Electrical Engineers in its constitution (Article II, Section 7) specifies that ''*graduation* from the electrical course of a school of engineering of recognized standing shall be considered as equivalent of *one year's electrical experience.*'' The American Society of Mechanical Engineers in its constitution (C9) specifies that ''*graduation* from a school of engineering of recognized standing shall be considered as equivalent to *two years* of active practise.'' The Western Society of Engineers in its constitution (Article III, Section 8) specifies that ''*graduation* from an engineering school of recognized standing shall be counted as *two years* of active practise.'' The same sort of provision exists in the constitutions of many of the local engineering associations (Louisiana Engineering Society, Florida Engineering Society, etc.), into which they have undoubtedly come by copying from the national societies.

Presumably the low recognition accorded to engineering study as compared with actual practise has arisen from the well-known and unchallenged fact that a raw technical graduate is not at first as useful as a young man who has spent as much time in actual practise as the graduate has spent in study. Nobody questions this fact; although one may well question whether, ten years later, the graduate is not then better qualified by more than the one or two years, to which the engineering societies count his graduation as equivalent.

The situation would not be so bad if the constitutions of the societies were drawn so that the technical graduate would be recognized as only two years behind his schoolmate of the preparatory school who has apprenticed himself in engineering without going to college. But this is not the case. The non-graduate engineer may have started into practical work before having obtained anywhere near the education which would even admit him to the freshman class of a reputable engineering school. Take the case of two boys about to enter high school. Let one take a job as a chainman on a survey party and work up from that. If he has native ability and determination to master the principles of his work and continues in it for five years, and then succeeds in getting into responsible charge of some construction work for a year more, he will have met the requirements—as far as experience is concerned—of an associate member in the American Society of Civil Engineers. Let the other boy complete his education. This will mean four years in the high school and then four years more in college. When he graduates he may find that his old schoolfellow has been an associate member of the A. S. C. E. for two years, and the same society will not admit the technical graduate to the same grade of membership without making him wait for *four years longer*. That is, with the same starting point it takes the better educated man just twice as long to obtain equal recognition from the society as the less educated one.

If the standards of engineering societies are to be fixed solely and absolutely by purely technical accomplishments, undoubtedly the societies are right in this sort of apparent discrimination against college men. Of late, however, there has been much disposition to insist that engineers should be men of breadth of view—which in most cases means men of some general education. There has been a feeling that engineering as a profession has not received the popular respect and recognition which it ought to have; and one of the commonest explanations proposed is that too many engineers whose competence in their own line is beyond question are lacking in that breadth of education which is usually possessed by other professional men.

If this is correct, and if the engineering societies are to stand for whatever raises the standing of the profession, then they ought to give better recognition to educational qualifications. This need not involve letting down the bars to inexperienced college graduates; the requirements could be left the same for them as in the past, but the amount of experience required of the non-graduate could be increased in proportion to the time when he has left school. In our imagined case of the two boys, the one who did not complete his education would be required to show twelve years of total experience instead of just six as at present.

A change in this direction would not be a discrimination against the man of native ability who has not had opportunities for formal instruction but has educated himself by his own efforts—a man who certainly deserves to be honored and who usually exceeds the average college graduate in force of character. Such a man would not have to wait any longer to receive recognition than if he had gone to college. The proposed change would merely mean that discrimination was not made *against the college-trained man,* as at present.

As a matter of fact I do not believe the provisions from the constitutions of the societies which have just been cited really represent any definitely-intended policy at the present day whatever. All the other societies have simply copied from the American Society of Civil Engineers which was founded in 1852, its present constitution being adopted in 1891. At the time of the foundation of the American Society of Civil Engineers, the engineering schools of this country were nothing like as well developed as at this time, nor was it as common for those who wished to become engineers to prepare themselves in college. Even since 1891, the time of adoption of the present constitution, there has been great advance in the character of instruction in the engineering colleges, as well as in the extent to which they are used by prospective engineers.

Yet recognition on the part of the engineering societies of these changed conditions has not been made. Meanwhile some states are passing laws to regulate admission to the practice of professional engineering. Requirements for admission to practice are very naturally based on those for admission to membership in national engineering societies. So the—presumably unintentional—discrimination against the college-trained engineer is spreading. It is high time that the national engineering societies revise their constitutions and adopt a twentieth-century attitude towards engineering education in their admission requirements.

ITEMS OF INTEREST.

THE SECRETARY OF THE NAVY.
WASHINGTON.

July 27, 1917.

My Dear Sir:

I have received your letter of July 25th, transmitting to me a copy of the Resolutions recently adopted by the Society for the Promotion of Engineering Education, and I thank you for sending them to me. The question of the withdrawal of large numbers of undergraduates from our engineering and medical schools for enlistment in the Army is, of course, a very serious one, and one which I am sure will have most careful consideration.

Sincerely yours,
JOSEPHUS DANIELS.

Mr. F. L. Bishop, Secretary,
Society for the Promotion of Engineering Education,
Pittsburgh, Pennsylvania.

UNITED STATES NAVAL ACADEMY, ANNAPOLIS, MARYLAND, DEPARTMENT OF MARINE ENGINEERING AND NAVAL CONSTRUCTION.

July 13, 1917.

My dear Dr. Bishop:

I want to express my appreciation of the excellent professional opportunity which came to me as a delegate to the Washington meeting of the Society for the Promotion of Engineering Education. Not only was the time spent in a valuable manner but in an enjoyable way.

I trust we shall have the pleasure of seeing you at Annapolis again and I know that you will be interested in hearing that steps are now being taken looking toward the construction of an excellent building for the Post Graduate School as recommended last year by your Society.

With kindest regards, I am,

Yours very truly,

W. T. Cluverius,
Commander, U. S. Navy.

Professor L. H. Harris, Assistant Secretary of the Society, who has been for some time Captain in the Engineer Officers' Reserve Corps, was called for active duty in August and is now in the Constructing Quartermaster's Department.

Due to the possible decrease in the membership and the income from dues on account of the war, the Executive Committee upon the recommendation of the Secretary has decided that the Secretary should not appoint an Assistant Secretary for the present year.

The Proceedings of the twenty-fifth meeting of this Society went to press in September and should be in the hands of all members who have paid their dues at this time. Great effort was made to get this out early because it was believed that the result of the meeting would be of benefit to the institutions at the opening of the school year.

In pursuance of the request of the institutional delegates at the Washington meeting, Commissioner Godfrey of the Advisory Commission of the Council of National Defense appointed the following committee: C. S. Howe, President, Case School of Applied Science; Milo S. Ketchum, Dean of Engineering, University of Colorado and president of this society; C. R. Mann, Carnegie Foundation for the Advancement of Science; S. P. Capen, Specialist in Higher Education, Bureau of Education; and F. L. Bishop, Dean of Engineering, University of Pittsburgh and secretary of this society, chairman. This committee is making a study of the relation of engineering schools to the national government during the present emergency. A preliminary report appears elsewhere in this number of ENGINEERING EDUCATION and a comprehensive report will be issued some time in October.

The various educational activities of the Advisory Commission of the Council of National Defense and war activities of the Bureau of Education have been combined in a coördinating executive committee made up of the following men: President Goodnow, Johns Hopkins University, chairman, representing the universities; President Pearson, Iowa State College, representing the land grant colleges; President Ferry, Hamilton College, representing the colleges of Liberal Arts; Dean F. L. Bishop, University of Pittsburgh, representing the engineering schools; and S. P. Capen, Bureau of Education, representing the Bureau of Education and the Executive Secretary of the Committee.

EDITORIAL.

We naturally expect that many changes will be evolved in education, particularly in engineering education, as a result of the present war. This has already demonstrated itself in many ways and the Committee on Engineering and Education of the Council of National Defense will have considerable to say in regard to this matter in its final report. But one very striking development is the commercial advertising of engineering education which was begun under a committee consisting of F. W. McNair, G. F. Swain, C. S. Howe, F. E. Turneaure, G. C. Anthony and M. S. Ketchum.

The editor believes that many young men in this country would attend institutions of higher learning and especially engineering schools, if these schools were brought to their attention in a concrete and concise way. It is remarkable that many young men in high school have no opportunity of becoming familiar with the aims and objects of engineering schools. Take, for instance, an ordinary high school in the city. All the teachers with the possible exception of those in manual training and physics are graduates of colleges of Liberal Arts where the training is such that they themselves have no possible conception of what the engineering profession is. It is practically impossible for the young men even in high schools to obtain such information. This is one reason why I believe it very desirable especially at this time of rapid development in engineering application not only to war but to industries, that the needs of the nation be brought to the attention of the young man by means of daily papers and magazines with which he comes in contact. Many schools heretofore have maintained advertisements to a greater or less extent in certain technical journals. These, of course, were excellent but how many high school students read high-grade technical journals? We should bear in mind in this connection that it is the young men largely who determine in this country where they are to go to school. Theoretically the parent does, but practically, it is left to the young man.

It seems to me that only good can result from this kind of a campaign. We must expect that it will be criticized; that some men who call themselves engineers will disapprove of it and some editors will undoubtedly find it a fruitful source of editorials. It, however, is right and will result in good to the nation and to the young men.

THE PROCEEDINGS HAVE BEEN ISSUED EARLY. THEY MUST BE PAID FOR FROM CURRENT DUES. IF YOU HAVE NOT PAID YOUR DUES FOR THIS YEAR, PLEASE SEND CHECK FOR $4.00 TO MR. W. O. WILEY, TREASURER, 432 FOURTH AVENUE, NEW YORK CITY.

COLLEGE NOTES.

University of Florida.—The State Road Department, which was established by the Legislature of 1915 with headquarters at Tallahassee, has established a branch office at the College of Engineering of the University of Florida. Besides serving as headquarters for work of the department through eastern and southern Florida this branch office will also have charge of all the testing of road materials done by the State Road Department. For this purpose the testing equipment belonging to the College of Engineering will be used, and for the further development of the testing laboratory the State Road Department and the College of Engineering will combine their efforts.

When the State Road Department was first established, every effort was made to have its headquarters placed at the College of Engineering of the university, and this was recommended to the legislature by the Florida State Good Roads Association; but the legislature saw fit to place the headquarters at the state capital. Now that the department has been established it has become so apparent that the facilities of the university would be of advantage to it that a branch has been established as noted.

Lafayette College.—Almon H. Fuller, dean of the School of Engineering at the University of Seattle, Washington, and one of the national leaders in engineering education, has accepted the appointment to the Head of the Department of Civil Engineering at Lafayette College which was vacated in June by the resignation of Professor J. Madison Porter. Professor Fuller will be supported by the same corps of assistants as Professor Porter had. Dean Fuller was selected for the post at Lafayette by a committee of alumni headed by Carroll P. Bassett, a well known engineer of Summit, N. J., and with him James Gayley of New York City, E. J. Fox, Esq., of Easton, Abraham Hogeland, chief engineer of the Great Northern Railroad, and Horace C. Booz, chief construction engineer of the Pennsylvania Railroad.

Dean Fuller is a graduate of Lafayette College. After his graduation he took post-graduate work at Cornell University as the McGraw Fellow in Civil Engineering. In 1899 he became professor of civil engineering at Washington University. One year later he was made dean of the department and since that time, through his efforts, this department has taken a place in the foremost ranks of the engineering schools of the country. Professor J. Madison Porter entered the Lafayette faculty in 1887 as an instructor in civil engineering. In 1890 he became full professor and headed the department. Through the twenty-seven years of his connection the civil engineering department at Lafayette College has become celebrated throughout the technical world. During the interim since the resignation of Professor Porter, Professor Harry T. Spengler has been acting head of the department. The other members of the faculty in civil engineering who assisted Professor Porter and who will remain in the department under Professor Fuller are Professor William T. Lyle, professor of municipal engineering; Professor Otho M. Graves, professor of graphics; Clifford E. Williams, instructor in cement engineering, Robert S. Johnson, instructor in civil engineering.

Donald B. Prentice, of the Sheffield Scientific School, of Yale University, has been appointed assistant professor of mechanical engineering at Lafayette, and has accepted the appointment. Professor Prentice will take charge of the work in boilers and heat engineering hitherto cared for by Professor Fitch.

Mr. Prentice graduated from Yale in 1910, and has been connected with the department at Yale since 1912. Mr. Prentice is married and will move to Easton and take charge of the work at once.

A. & M. College of Texas.—James C. Nagle has been appointed dean of engineering and professor of civil engineering in the Agricultural and Mechanical College of Texas, succeeding D. W. Spence, whose death occurred in June.

Mr. Nagle is a Virginian by birth, but most of his life has been spent in Texas. He graduated from the University of Texas in 1889 with a B.S. degree in engineering, and obtained an M.A. degree in 1892. In the same year he obtained a C.E.

degree from the Western University of Pennsylvania, now the University of Pittsburgh, and in 1893 an M.C.E. degree from Cornell.

He was a professor of civil engineering in the Agricultural and Mechanical College of Texas for about twenty years, and in 1911 was also made dean of engineering. He resigned from this position in 1913 to become chairman of the Texas board of water engineers, and has occupied that position since then. During his professional career he has often been engaged on construction work of various kinds, principally railroad, bridge and irrigation work.

Mr. Nagle is the author of a field manual for railroad engineers and of numerous technical papers. He is a past president of the Texas Association of Members of the American Society of Civil Engineers; past president of the Texas Academy of Science and a major in the Engineers' Reserve Corps.

B. K. Coghlan has resigned as associate professor of highway engineering at the Agricultural and Mechanical College of Texas. He is captain in the Engineer Officers' Reserve Corps and has been ordered to Ft. Leavenworth.

E. O. Francisco, who was assistant professor of civil engineering at the Agricultural and Mechanical College of Texas during the last session, has been commissioned a second lieutenant in the Engineer Officers' Reserve Corps and has been ordered to Ft. Leavenworth.

PERSONALS.

Professor A. M. Buck, who for the past six years has been in charge of the electric railway courses at the University of Illinois, has resigned to join Mr. John A. Beeler of 52 Vanderbilt Avenue, New York City. His new work will consist largely of investigations dealing with the construction, operating, and management of electric railway properties. At present he is assisting Mr. Beeler in reporting on the operations of the Boston Elevated Railway to determine if the net revenue can be increased by the addition of operating economies. This work is being done for the Public Service Commission of Massachusetts in compliance with an act passed at the last session of the legislature.

Professor W. S. Franklin, formerly of Lehigh University, has accepted a position as Special Teacher and Lecturer at the Massachusetts Institute of Technology, partly in the Department of Physics and partly in the Department of Electrical Engineering. Professor Franklin requests his numerous correspondents to note his new address.

COPY.

August 31, 1917.

From: The Adjutant General of the Army.
To: The Commanding General, 76th Division, National Army,
Camp Devens, Ayer, Massachusetts.
Subject: Assignment of drafted men to organization.

A careful study will be made of the abilities of the men of your command who have been drafted into the service with a view to ascertaining special qualifications for duty in the different branches of the service; and drafted men who have graduated from, or been students in scientific or technical departments of colleges or universities should be assigned to the branches of the service for which their previous training qualified them.

By order of the Secretary of War:

(JOHN S. JOHNSTON)
Adjutant General.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

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Milo S. Ketchum, G. R. Chatburn, F. L. Bishop, *Editor*.

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THE INDICATIONS OF A NATURAL APTITUDE FOR MECHANICAL ENGINEERING.

BY SANFORD A. MOSS,

Lynn, Mass.

The writer firmly believes that a person is successful in any career because of a fundamental natural aptitude, of course developed by education. Neither aptitude alone, nor education alone, accomplish much, but the combination gives success.

It follows that it is necessary that a young man should select a profession which suits his natural abilities. He should choose to be a doctor or a lawyer or a civil engineer, or any one of a thousand other things in accordance with his native aptitude. The writer believes that observation of the play and natural preferences of a boy and youth will give indication of fundamental aptitude, and this theory is elaborated below for the case of mechanical engineers.

A grave responsibility also rests upon the faculty of a college which undertakes the training of a youth, and there should be certainty that aptitude exists. It should not be possible for a student to waste one, two, or three years in study for a certain profession, only to find that he is not fitted for it. The writer believes that examination by the faculty, of the marks received in certain subjects in the first year of a mechanical engineering course will indicate whether or not aptitude exists for this profession, and this matter is also elaborated below.

If only we could use astrology or phrenology to guide us in these matters! If only we were born with a little tag indicating the career we should select! Possibly at some future date there will be devised definite methods whereby a person's aptitude may be found, and which will definitely rate him just as the Binet-Simon tests rate the intelligence of a child. In default of such definite criteria a few thoughts are given in connection with mechanical engineering alone, with the hope of creating discussion and doing a little to assist in the solution of a very important problem. Something will be accomplished if nothing more is done than the direction of attention to the problem. If the ideas given have any merit, similar ones should be presented by members of other professions.

The seeming attitude of a college faculty which undertakes the education of a young man is the assumption that he knows what he is doing when he registers for a certain course. We will first suppose this a proper point of view and that it is wholly the responsibility of the young man to make a proper selection, and that the university is not in the least interested. What then are the signs which should lead a young man and his parents to select the career of a mechanical engineer?

Discussion of this subject with a great many successful engineers seems to indicate that the requisite things are ability at elementary mathematics and a liking for machinery. There should be study by the young man and his parents as to whether as a child and a boy there has been this liking for elementary mathematics and for machinery. Did the boy even when ten or twelve like to fix up things around the house, repair furniture, fix the lawn mower or clothes wringer, and prefer mechanical toys? Did the boy when twelve or sixteen make water wheels or engines or mechanical playthings of any kind no matter how crude? Did he like to watch machinery in motion and to ask questions as to how machinery operated? Was he inquisitive as to the "reason why" in mechanical matters? One thing which all engineers with whom the writer has talked did, when boys, was to tinker with clocks and watches. In fact, the writer almost believes if a boy has never taken a clock apart as a matter of interest, that he will never become a successful mechanical engineer. This tinkering with machinery need result in no highly finished product. The actual results may be extremely crude. The machines constructed may never operate. The thing which is to be sought for is a natural liking for moving machinery during childhood.

Such instincts as those mentioned probably exist in the case of a boy fitted to become a mechanic of any kind, as well as a mechanical engineer. That is to say, a boy who exhibits such traits may be fitted to become either a skillful mechanic, a shop foreman, a power plant operator, a construction foreman, or anything else intimately connected with machinery. The criterion which indicates that the boy should finally go to college and take up a course in mechanical engineering is the additional liking for elementary mathematics. The boy must be good at grammar school arithmetic problems, high school algebra and geometry, and possibly also at high school physics. Ability in manual training work in the high school is often taken into account. However, excellence in manual training work is often merely an indication of general dexterity with the hands, and this is not an essential for a mechanical engineer. Many a good mechanical engineer would make a poor machinist. There is no necessary connection between manual dexterity, and mental ability to handle engineering problems.

It is quite probable, as a result of careful study by a young man of college age, and by his parents and teachers, in the general directions above mentioned, that a proper decision may be arrived at as to whether or not a course in mechanical engineering should be undertaken. But unfortunately such careful study is not often given. Fortunately present-day American boys do not have professions selected for them in order of their birth, the oldest son to the military professions, next to law or medicine, and next to theology. However, even though we are beyond this stage, many professions are selected on insufficient grounds. A profession is often selected because some friend has done well at it, or because it seems to be a rising business, or because there are good opportunities for making money, or for many reasons other than that the young man has natural adaptation. It should be the duty of college officials to discover such cases and prevent the pursuit of an improper course. What then are the college courses which should primarily be considered, in arriving at the decision as to whether the student should continue in mechanical engineering?

The situation is complicated by the fact that undergraduate work in mechanical engineering is devoted only to instruction in fundamentals used by the professional engineer. There is little actual contact with the sort of problems which the practicing engineer must solve in designing, constructing, and operating machinery. The nearest approach is found in the customary courses in machine design, kinematics and mechanism, machine drawing, mechanical laboratory and experimental engineering.

In order to ensure success in mechanical engineering there should be proficiency in such a group of courses. There should also be proficiency in physics, and in elementary college mathematics. This probably completes the list where proficiency is an absolute necessity. There are a great many other things in which proficiency is desirable, but not imperative. This includes languages, higher mathematics, calculus, mathematical thermodynamics, mathematical hydrodynamics, and manual dexterity in shop work.

It is obvious that it would be desirable to have as many of the courses as possible of the group in which proficiency is essential, given in the freshman year. This can certainly be done with physics and elementary mathematics. It is not, however, now customary to give subjects such as machine design, kinematics and mechanism, mechanical laboratory and experimental engineering, in the freshman year. The writer proposes, however, that courses should be rearranged so that this can be done.

In a preceding article* the writer has endeavored to demon-

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*"On the Natural Method of Learning," *Engineering Education*, p. 145, No. 3, Vol. VII.

strate that it is possible, and in some cases desirable, to give such courses without previously having given the traditional preparatory courses. For instance, mechanical laboratory and experimental engineering, if given in the freshman year, would require that a great many principles, formulas, and methods be given to the pupil arbitrarily for use in working up the tests. All of these principles, formulas, and methods would at a later point in the college course be developed rationally. The writer believes that the student would be very much better able to learn about this rational development if he had previously used the subject matter in his mechanical laboratory work in an empirical way. Similar remarks apply to machine design. In other words, the proposed plan is a positive advantage from an educational point of view, independently of the advantage from the point of view of the present article.

A procedure such as that proposed would put the pupil in actual contact with mechanical engineering matters in the freshman year. This would enable the pupil and the faculty to reach a conclusion as to whether there was sufficient proficiency to warrant the continuation of the course.

In some cases the freshman college year is devoted to training in engineering in general without any specialization for mechanical, civil, or electrical branches. In such cases a similar procedure could be adopted and the first year's course could be arranged so that the marks would indicate whether there was aptitude for engineering in general.

The second year's work for mechanical engineers would then be laid out as above indicated, and the marks would indicate whether or not selection of this particular branch of engineering had been correctly made.

THREE–PHASE LABORATORY PLUG BOARD.

BY F. W. SPRINGER,

Professor of Electrical Engineering, University of Minnesota.

As shown in the figure, three 15-K. W. transformers are connected in delta to a 2,300-volt, 60-cycle, 3-phase power line and the three independent 115–230-volt three-wire secondaries are carried through fuses, three 3-wire single-phase watt-hour meters, and circuit breakers to the plug board. Each terminal of the three-phase secondaries ends in a four-point terminal on the board for convenience in multiple plugging.

The board is used as a source of single- or three-phase power in testing motors, etc., the various combinations of 115–230 volts sources in delta, star, etc., giving a considerable choice of voltages. The board also offers opportunity for experimentally demonstrating the relations of voltages and phase angles when connecting independent voltages, having 120-degree phase relations, in delta, star, etc.

THREE-PHASE LABORATORY PLUG BOARD.

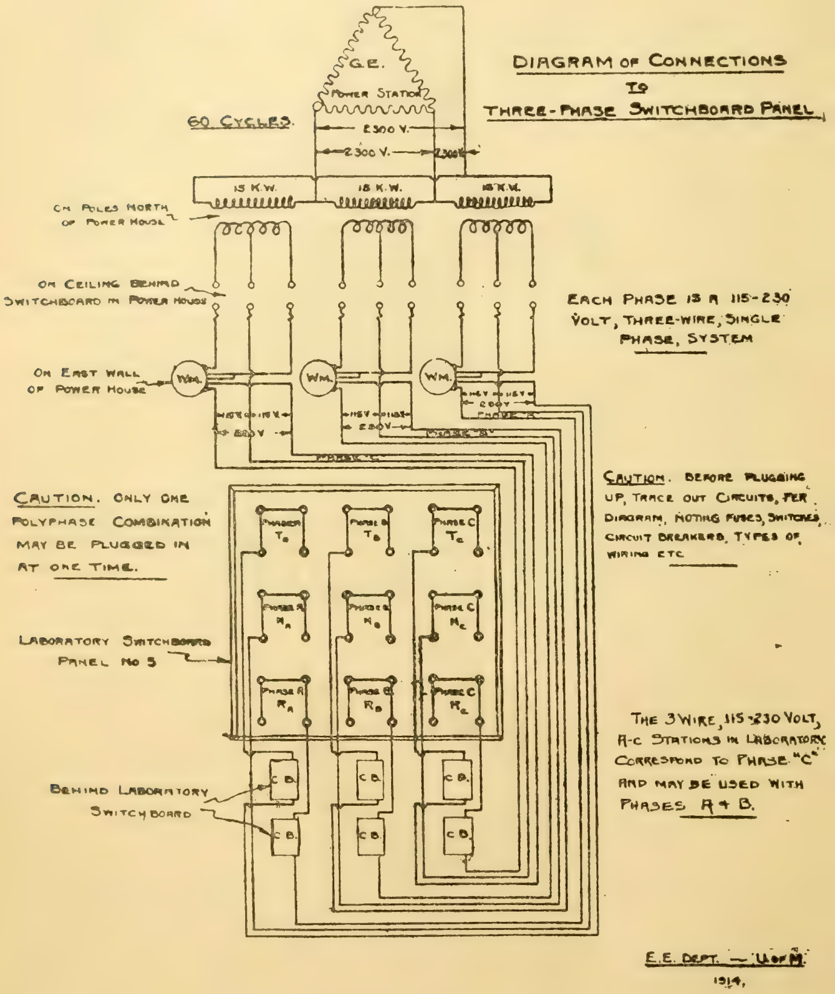


DIAGRAM OF CONNECTIONS
TO
THREE-PHASE SWITCHBOARD PANEL
G.E.
POWER STATION
60 CYCLES.
2300 V.
2300 V.
2300 V.
15 K.W.
15 K.W.
15 K.W.
ON POLES NORTH OF POWER HOUSE
ON CEILING BEHIND SWITCHBOARD IN POWER HOUSE
EACH PHASE IS A 115-230 VOLT, THREE-WIRE, SINGLE PHASE, SYSTEM
ON EAST WALL OF POWER HOUSE
W.M.
W.M.
W.M.
115 V
115 V
230 V
PHASE "A"
PHASE "B"
PHASE "C"
CAUTION. ONLY ONE POLYPHASE COMBINATION MAY BE PLUGGED IN AT ONE TIME.
CAUTION. BEFORE PLUGGING UP, TRACE OUT CIRCUITS, PER DIAGRAM, NOTING FUSES, SWITCHES, CIRCUIT BREAKERS, TYPES OF WIRING ETC.
PHASE A
T_A
PHASE B
T_B
PHASE C
T_C
PHASE A
N_A
PHASE B
N_B
PHASE C
N_C
PHASE A
R_A
PHASE B
R_B
PHASE C
R_C
LABORATORY SWITCHBOARD PANEL No 5
THE 3 WIRE, 115-230 VOLT, A-C STATIONS IN LABORATORY CORRESPOND TO PHASE "C" AND MAY BE USED WITH PHASES A + B.
BEHIND LABORATORY SWITCHBOARD
C.B.
C.B.
C.B.
C.B.
C.B.
C.B.
E.E. DEPT. — U. of M.
1914.

PORTABLE POLYPHASE SWITCH BOARDS.

BY F. W. SPRINGER,

Professor of Electrical Engineering, University of Minnesota.

The figures illustrate two portable polyphase switch boards for pedagogical purposes. Westinghouse and General Electric central station instruments are used respectively on the two boards. Each board is supplied with two sets of current transformers connected with suitable double throw switches, giving two current ranges. The potential transformers have several taps giving voltages up to 300 volts.

It is planned to build a third board arranged to make use of portable current and voltage transformers so that much wider voltage and current ranges may be obtained.

The common uses of the board may be briefly outlined in detail as follows:

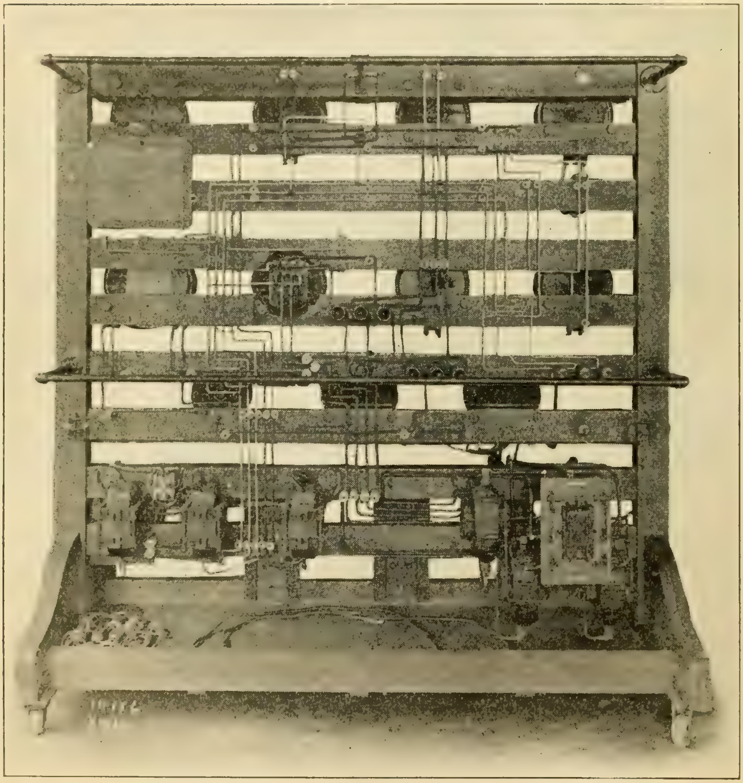
1. An exhibit of individual central station instruments.

2. The cases of the instruments are frequently removed in order to study the principles of design and operation of the various instruments.

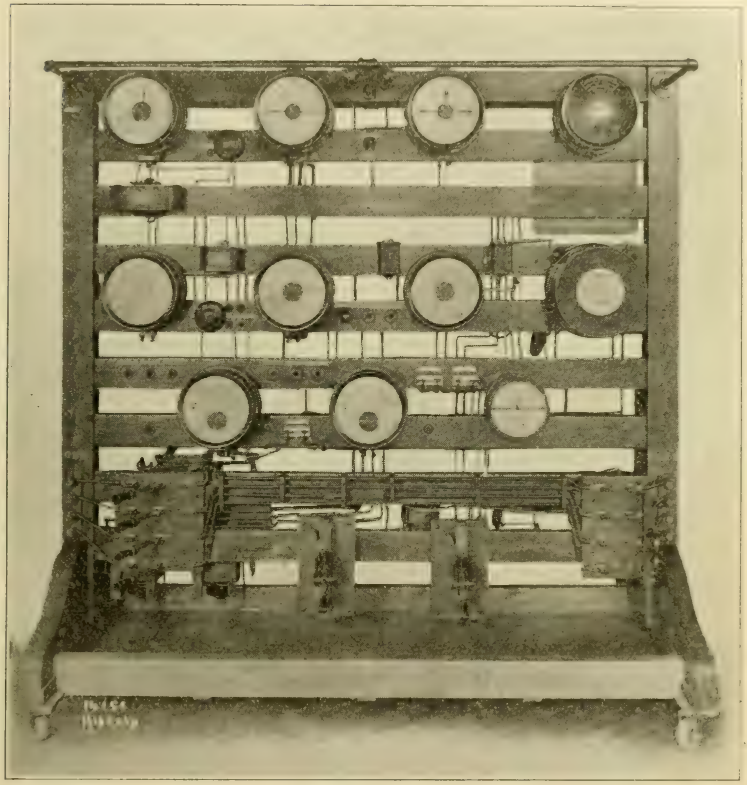
3. Calibration and inter-comparison as of the wattmeters, ammeters, voltmeters, power factor meters, etc.

4. Illustrations of the principles of the methods of connecting polyphase central station instruments, made particularly clear by the use of white, insulated wire for the potential circuits and also by suitably grouping these circuits and by using different sizes of the wire for the other circuits. The switch board is accompanied by blueprints on compo board showing the wiring both from the front and from the back. The skeleton frame makes circuit tracing a simple matter.

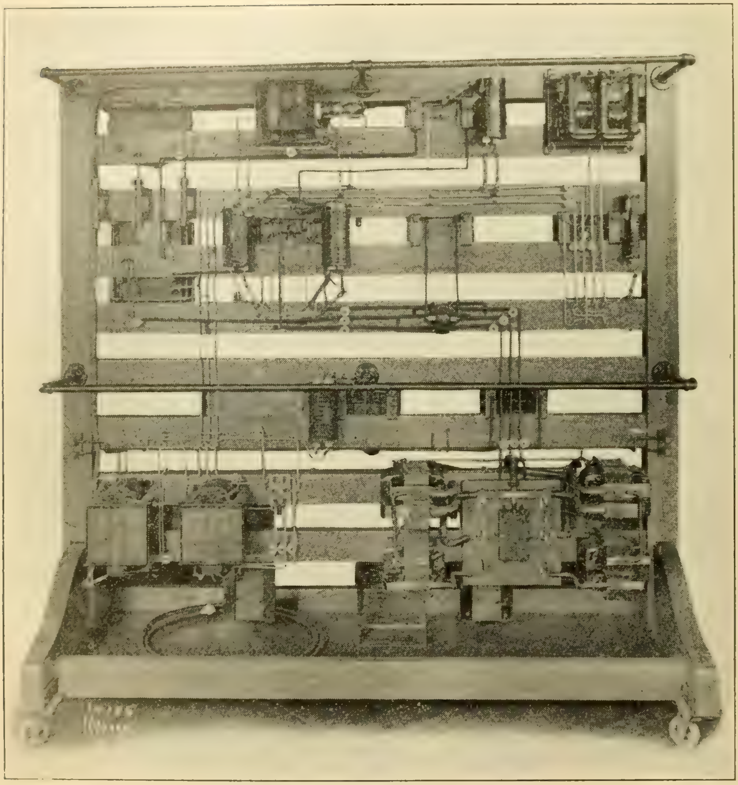
5. The boards are frequently used in behavior or operating tests in order to illustrate general principles, especially those arising in starting machines of various types.



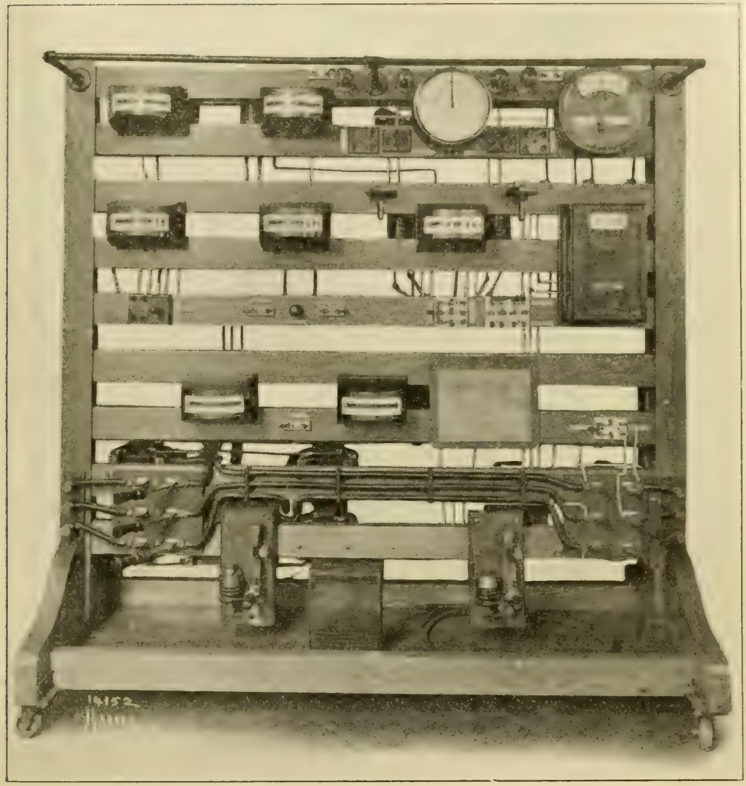
Back View, Westinghouse Board.



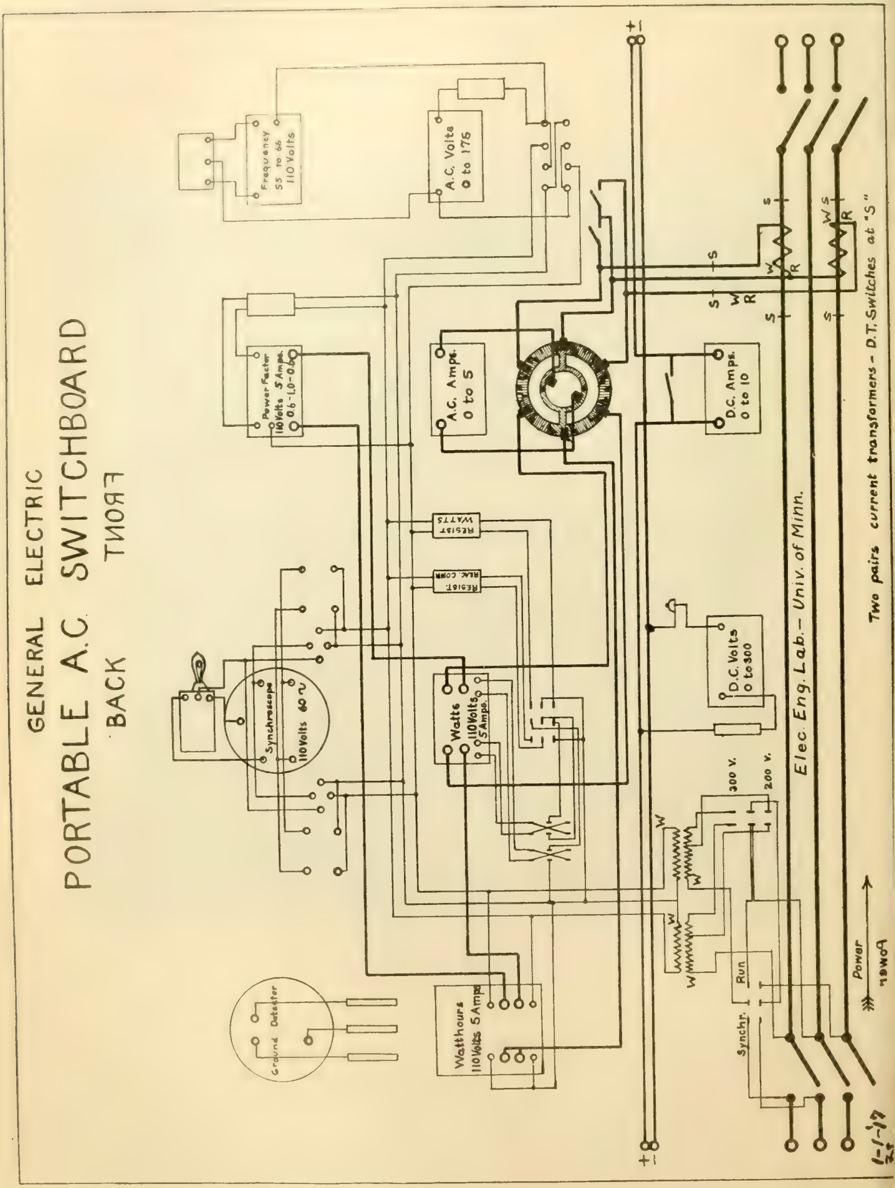
FRONT VIEW, WESTINGHOUSE BOARD.

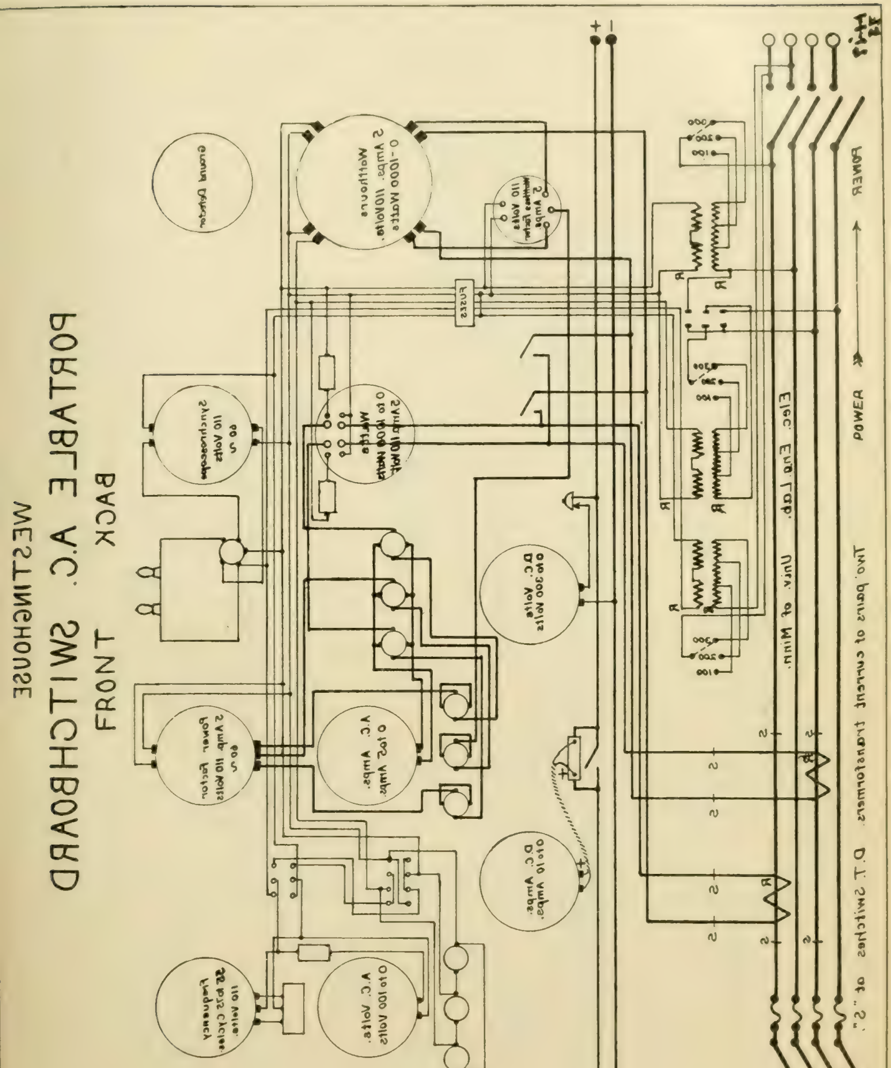


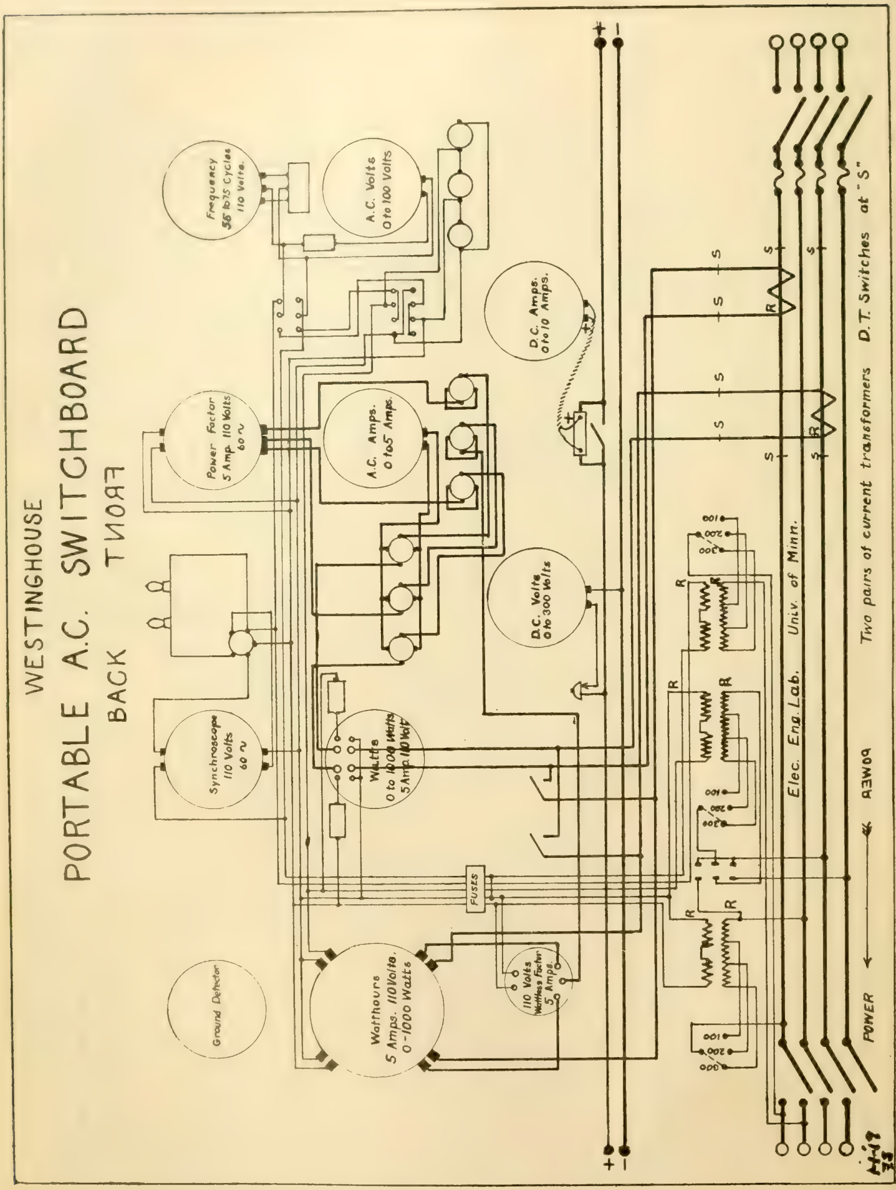
BACK VIEW, G. E. BOARD.

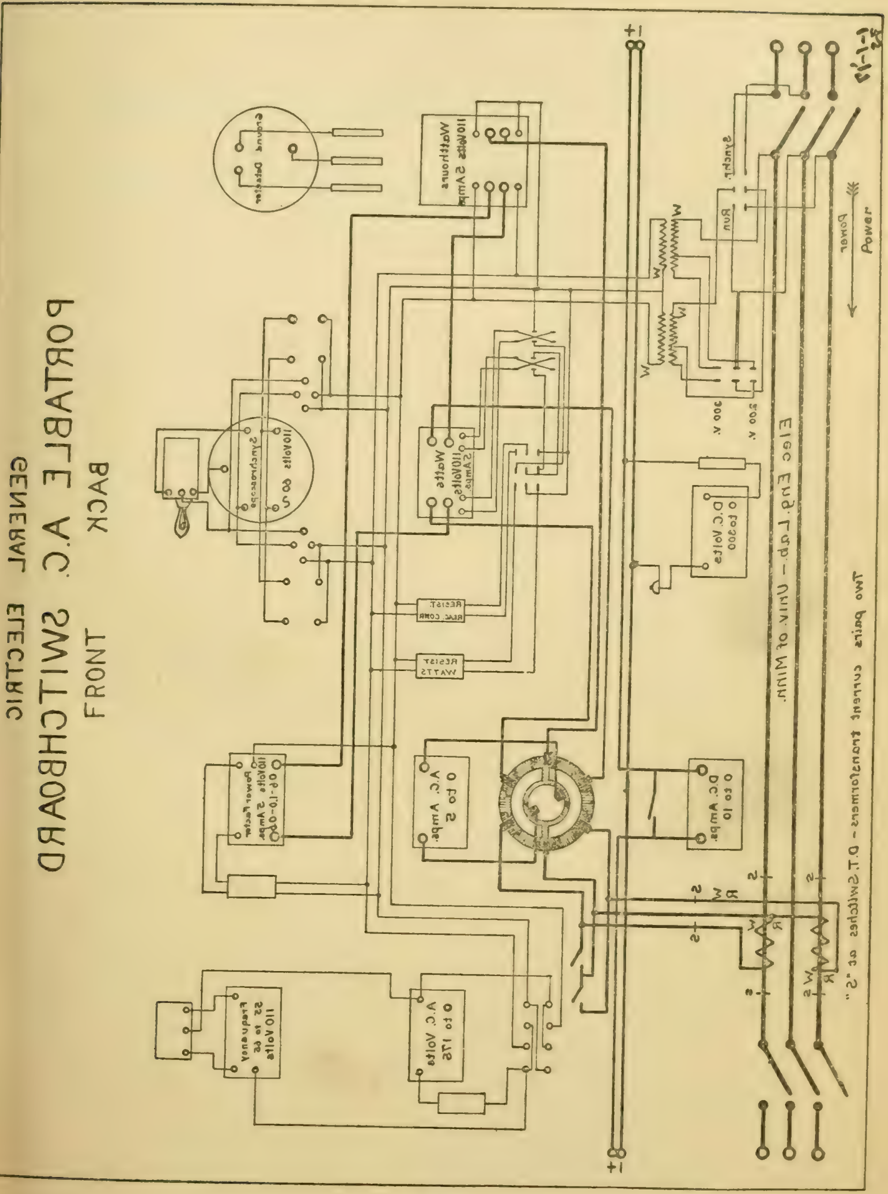


Front View, G. E. Board.


GENERAL ELECTRIC
PORTABLE A.C. SWITCHBOARD
BACK
FRONT
Frequency 55 to 66 110 Volts
A.C. Volts 0 to 175
Power Factor 110 Volts 5 Amps. 0.6-1.0-0.6
A.C. Amps. 0 to 5
D.C. Amps. 0 to 10
RESIST WATTS
RESIST. REAC. COMP.
Synchroscope 110 Volts 60~
Watts 110 Volts 5 Amps.
D.C. Volts 0 to 300
200 V.
200 V.
W
W
W
W
S
S
W
R
S
S
W
R
W S
R
Ground Detector
Watthours 110 Volts 5 Amps
Synchr.
Run
Power
Power
+
–
+
–
Elec. Eng. Lab. – Univ. of Minn.
Two pairs current transformers – D.T. Switches at "S"
1-1-'17


WESTINGHOUSE
PORTABLE A.C. SWITCHBOARD
FRONT
BACK
Ground Detector
Watthours 5 Amps. 110 Volts. 0-1000 Watts
110 Volts 5 Amps
FUSES
Synchroscope 110 Volts 60 ~
Watts 0 to 1000 Watts 5 Amps 110 Volts
D.C. Volts 0 to 300 Volts
Power Factor 5 Amp. 110 Volts 60 ~
A.C. Amps. 0 to 25 Amps.
D.C. Amps. 0 to 10 Amps.
A.C. Volts. 0 to 100 Volts
Frequency 110 Volts 55 to 75 cycles
Elec. Eng. Lab. Univ. of Minn.
Two pairs of current transformers. D.T. Switches at "S".
POWER
POWER
100
200
300
R
S
+
-


WESTINGHOUSE
PORTABLE A.C. SWITCHBOARD
BACK
FRONT
Frequency 55 to 75 Cycles 110 Volts.
A.C. Volts 0 to 100 Volts
D.C. Amps. 0 to 10 Amps.
Power Factor 5 Amp. 110 Volts 60 ~
A.C. Amps. 0 to 5 Amps.
D.C. Volts 0 to 300 Volts
Synchroscope 110 Volts 60 ~
Watts 0 to 1000 Watts 5 Amp. 110 Volts
Ground Detector
Watthours 5 Amps. 110 Volts. 0-1000 Watts
110 Volts Wattless Factor 5 Amps.
FUSES
S
R
100
200
300
+
-
Elec. Eng. Lab. Univ. of Minn.
Two pairs of current transformers D.T. Switches at "S"
POWER
POWER


GENERAL ELECTRIC
PORTABLE A.C. SWITCHBOARD
BACK
FRONT
Ground Detector
Watthours 110 Volts 5 Amps.
Synchroscope 110 Volts 60 ~
Watts 110 Volts 5 Amps.
RESIST. REAC. COMP.
RESIST. WATTS
Power-Factor 110 Volts 5 Amps. 0.5-1.0-0.5
A.C. Amps. 0 to 5
Frequency 55 to 65 110 Volts
A.C. Volts 0 to 175
D.C. Volts 0 to 300
D.C. Amps. 0 to 10
300 V.
200 V.
Synchr.
Run
Power
Power
W
R
S
+
-
Elec Eng. Lab. - Univ. of Minn.
Two pairs current transformers - D.T. Switches at "S"

6. In solving central station problems, some of which arise during the summer vacation work of students in central stations, also in connection with standard central station operating problems, such as synchronizing, power factor changing, etc.

7. The boards are sometimes used in performance tests of motors, generators, transformers, etc., where the greatest possible accuracy is not demanded.

ENGINEERING GRADUATES AND INDUSTRIAL DEMANDS.

BY L. W. W. MORROW,

Associate Professor and Acting Director, Dept. of Electrical Engineering,
University of Oklahoma.

The current technical press has contained several articles regarding the capabilities of engineering graduates in the industrial world. At the meetings of the various technical societies there have been frequent criticisms of present educational methods and engineering curriculums.

It is alleged that the present curriculums are unsuited for modern industrial conditions; that educators are too academic and are not in touch with the progress of industry and the problems encountered in the commercial field; that educational methods are antique and inefficient; that the content of the curriculums is out of date and unbalanced.

Charges are made that engineering graduates are lacking in thorough training and knowledge; that they use bad English; that their knowledge of fundamentals is very hazy; that their training makes them more suited for designers than anything else; that graduates have no knowledge of commercial methods, apparatus or economics; that as a whole the graduates have a hazy idea of several things but accurate knowledge of none.

It is stated that engineering graduates are from one pattern; that initiative and personality are repressed rather than cultivated; that they have become inaccurate and lazy through improper training.

Other criticisms are made but, in general, the foregoing statements express the sentiments of those advocating reform in curriculums and educational methods. The men who make the criticisms are industrial engineers; men who judge engineering schools by their product and its fitness for their requirements; men who demand efficient employees; men whose viewpoint is necessarily that due to their environment.

These men are unaware of the fact that engineering educators have been working to improve curriculums and educational methods for the past ten years through the Society for the Promotion of Engineering Education; they do not know of the great strides made in the field of engineering education. Their criticisms are strictly selfish and are made solely from a commercial viewpoint.

On the other hand there are enough criticisms to cause engineering educators to pause and consider them. The criticisms may be just in some respects; there may have been too great a tendency to remodel and change engineering educational methods and curriculums from a purely academic point of view. From an analysis of the criticisms it may be possible to consider more specifically industrial demands. At all events the criticisms should be considered with a view to eliminating them through educational campaigns or through educational changes.

A consideration of the points alleged leads inevitably to a historical sketch of the growth of engineering and changes in industrial conditions; the growth of the engineering school and finally the changes in the relations between the schools and the industrial world.

Historically, engineering may be divided into three eras, each era being determined by the chief industrial demand. These eras are as follows in point of time: the era of the designer and inventor; the era of the operator and constructor and finally the era of the specialist and executive.

The demand for inventors and designers was greatest at the beginning of the so-called industrial age. The invention of the cotton gin, power loom, steam engine, machine tools; the discovery of new forces for use in transportation and communication and for the transformation of energy; the development of the factory and concentrated manufacture as against the individual producer, all these things created a great demand for inventors and designers—men who were qualified by fundamental knowledge of science to design and produce new machines, to discover new applications for available forces and to investigate existing forces with a view to developing machines for commercial applications.

The years from 1890 to 1900 saw the multifarious applications of the forces, materials and ideas developed during the previous era. The railway, the telephone, the power plant, the steam engine, the electric motor and generator, the turbine and water wheel, the machines for the manufacture of diversified products—all these were developed and applied with great rapidity.

The great development in commercial applications of engineering machines created a demand for skilled operators and constructors. Men were desired who were capable of constructing machines from design drawings; men were wanted in the drafting rooms to make the drawings; men were wanted to operate the engines, machines and power plants used for commercial purposes. The combined demands for the above types of men were so great that the industries were forced to train men through the adoption of the apprenticeship system.

The years from 1900 to the present time were noted for the concentration of power production; of manufacture; of sales organizations; of financial resources. The industrial world was organized and concentrated for economical reasons. The engineering fields were divided and subdivided for reasons of efficiency. It was an era of efficiency and economy in design, operation and production. The industrial world desired executives, highly trained specialists in engineering, organizers, business managers and financiers in connection with its engineering and industrial problems and conditions.

The foregoing historical divisions of the industrial age are not strictly accurate as each division is not a discontinuous function of time. There is a demand for all types of men at the present time; as the limits in industrial developments have never been ascertained, however, the most insistent demand is as outlined and the supply is least. The demand for designers, operators and constructors has been greatly lessened by the increased supply of such men developed by the industries and the technical schools. The gage of the peak demand for men is found in the salaries. At this time few designers, operators or constructors receive $10,000 per year, yet many executives, specialist engineers, sales engineers, consulting engineers and efficiency engineers receive that figure. $50,000 would be a better comparative figure as regards the number of men receiving such salaries in the two classes.

The engineering school is a product of the industrial age and is a result of industrial demands. It was born in the inventive era and was a direct result of the desire for men who had fundamental training in science sufficient for them intelligently to use the newly discovered machines, forces, materials and processes. The engineering school grew gradually from a school of pure science to one of applied science because of the insistent demands of industries. The growth and evolution of curriculums were slow processes and lagged far behind industrial demands as regards time.

The era of application and operation gave an impetus to engineering schools that has existed almost to this time. The demands for skilled operators, draftsmen and mechanics were so great that industrial organizations were forced to supply some of the men through apprenticeship systems. The engineering schools were insufficient in number to fill the demand for their products. New engineering schools were founded in great numbers. The field of pure and applied science was sharply divided and defined in this era. The engineering curriculums were changed in order to train students in the use of industrial apparatus in wood and machine shops and in testing laboratories for steam and electric machines. The schools devoted a great amount of time to design and drafting and also taught the fundamentals of engineering as contained in the pure sciences. This was the golden age for engineering schools—their products were in great demand and excited no criticism; the engineering profession was very popular and caused the schools to receive private and state support as well as a great increase in the number of students.

The era from 1900 to date, with the resulting changes in industrial conditions and demands, has greatly changed the working conditions for engineering schools and caused some dissatisfaction with their products. The popularity of engineering as a profession created in the previous era caused a large increase in enrollments for several years and in the number of engineering schools. These conditions existed long after the initial industrial impetus had ceased. The schools still kept in view the training of designers and operators although the demand for such men was decreasing yearly. Engineering schools continued to add large and expensive shops and laboratories to their equipment; some even attempted to manufacture commercial products in order to train students in commercial methods. The apex of this condition as regards the engineering schools was reached long after industrial demands had changed. The time lag between school curriculums and industrial conditions is very great and can only be shortened by more intense coöperation between the schools and the industries through faculty associations with industrial pursuits.

The engineering schools awoke to existing conditions in industrial pursuits only a few years ago—the prime source of awakening being a decrease in engineering enrollment. This was explained in part by the growth in popularity of agriculture at this period, but this alone could not be sufficient reason for the decrease in the popularity of engineering as a profession. Upon investigation, the schools found that the industrial conditions and demands had changed. Industry now desired specialist engineers—a man who was not only an electrical engineer but also a specialist in one branch of electrical engineering such as railways, telephony, illumination, transmission, etc. The engineering problems were largely problems in economics and no longer those of design or operation. The industrial world also desired executives and business managers and could not obtain a sufficient number. Industry was looking to the engineering schools for their supply and found it unfitted for the existing conditions.

The schools found it advisable to conform to industrial demands as their salvation and life depended upon their products obtaining larger salaries than were being given them. In a haphazard way and at different times the schools began to change their curriculums to conform to the new conditions. In this revision of curriculums, instead of omitting previous courses and replacing them by others of the desired type, they simply added to the existing curriculum specialized courses in engineering, economics, business law and business management and made no attempt to increase the time alloted for an engineering degree. Civil engineering students for instance were not only given the previous content of the curriculum but were also given specialized courses in concrete construction, hydraulic engineering, structural engineering, railroad and highway engineering, economics, English, business management and business law. The same conditions held true in electrical and mechanical engineering.

During the elapsed time the knowledge of fundamental laws and their applications had increased and so required more time for their assimilation with the same degree of thoroughness.

What was the result? The schools founds they had attempted the impossible; they found that it was impossible to have such curriculums in a four-year course. They found their graduates were not thoroughly trained even in fundamentals; that their reputations were on the wane; that their enrollments were decreasing as a consequence; that criticisms were severe; that radical steps must be taken to avert disaster. The realization of this condition was a slow process and was marked by no organized effort, on the part of the schools, to revise their educational methods and curriculums. Even now a great many schools do not realize that such conditions exist and have taken no steps to analyze the trend of engineering education. The situation is aggravated by the demands of industries for the type of men that cannot be furnished by engineering schools in a four-year course; the industries do not realize the conditions engineering educators face or the problem they have to solve—industry demands results irrespective of conditions. The schools have proven through costly experimentation that the type of men demanded is an impossibility yet some schools are still trying to supply the demand.

The industrial engineers desire men trained in fundamentals, operation, design and construction and specialized engineers along one line; they desire men trained in economics, business organizations and executive duties. They criticize the schools because they do not furnish such men in a four-year course.

The schools should admit without question that they fail to supply the demand; that they cannot do so under present conditions in a four-year course. It is impossible to train a high-school graduate in four years so that he will possess all the qualifications demanded by industries. The schools should admit these facts and submit their brief to industrial engineers.

Engineering schools are facing a crisis. Industry demands results that are not forthcoming. The lives of engineering schools depend upon their supplying the demands of industry. The problem must be solved and will only be solved by the efforts of engineering educators for they are the ones vitally interested. An educational campaign is the first step in the solution of the problem. Industry and industrial engineers must be made to realize that they are demanding the impossible. That engineering schools have attempted to supply such men and found it impossible with the result that the schools have been criticized because their products are inaccurate, hazy and ill trained in many respects.

What is the solution of the problem? How can industrial demands be satisfied?

A six-year course has been offered as a panacea. The objection to the six-year course is the time required. Industries have offered no inducements to cause men to take six-year courses. Curriculums for six-year courses are very immature at the present time. Such a course requires a strong graduate faculty as the time has not arrived for abolishing the four-year course. The criticisms that curriculums are faulty, that all students are given the same training; that initiative is not developed; that there are no facilities for training in commercial operation, methods, processes and executive duties—all these conditions cannot be changed by simply spreading out the present curriculums over two more years.

Six years is required to give accurate and thorough training in the fundamentals of engineering and some specialized training in a main division of engineering such as civil, electrical or mechanical. The engineering schools are equipped to give such training as to faculty and apparatus. It is feasible to balance curriculum content and to allow for the natural aptitude and personality of students. From the above considerations it would seem that the addition of two years would not help to supply the commercial demand except by removing the criticism as to inaccuracy in fundamentals. It would merely give the student a proper foundation.

Commercial methods in manufacture, operation and construction can only be obtained through academic and commercial coöperation. It is impossible for the schools to have up-to-date equipment on a commercial scale. This criticism could be readily removed however, through coöperative effort. Students could be required to work in the industrial world at least two summers before a degree is granted. The type of work, pay, etc., could readily be worked out in specific cases. This field offers a splendid opportunity for development and should be considered by engineering educators.

Fundamental training in engineering is the best foundation for executives and organizers. It is not possible to give more than this foundation in a four-years course, so the only way this demand can be filled is through the graduate school. There is no place for such special training in the four-year course and students will not take graduate work unless there is some inducement for such work. This condition holds true for specialists in one line of engineering. The schools should remove all specialization from their four-year courses. They should develop strong graduate schools, they should obtain the coöperation of industries and offer inducements to proper men to pursue the graduate courses.

Taking up the chief criticisms, it is found that in many cases engineering graduates of recent years have lacked thorough and accurate training in engineering. This was due to faults in the curriculums and methods of teaching and also due to the attempt of industrial engineers to get the impossible. This condition and the above criticisms can be removed through removal of specialization, balancing the fundamental curriculum content and educating the industrial engineers.

The supply of specialists and executives demanded by industrial engineers can only be obtained through strong graduate schools. The graduate schools can only be developed through coöperative effort.

The knowledge of commercial apparatus and methods demanded by industry can be obtained through required commercial summer work, provided industries coöperate with the schools to offer some inducement for such work.

The schools should bear in mind the fact that their function is to furnish industrial engineers and should not be too academic in their aims and curriculums. The present curriculums of engineering schools show a startling difference in content. There is no uniformity in curriculum content, time alloted the different courses or methods of presentation. It seems feasible to have a better agreement among engineering schools as to the above points.

The industrial world should be made aware of educational conditions through an educational propaganda; should be taught what to expect of four-year engineering graduates;

should be strongly urged to coöperate with the schools as to summer work and, finally, should offer inducements to students to pursue graduate work so as to cause the development of strong graduate schools.

Some of the criticisms are well founded and can only be removed by conscientious effort of engineering educators, other criticisms are not logical and are made through ignorance of the conditions and results possible in engineering education.

A STUDY OF THE EARNINGS OF CIVIL ENGINEERING GRADUATES.

BY LOUIS MITCHELL,

Associate Professor of Civil Engineering, Syracuse University.

During the past year the writer attempted a study of the earnings of the graduates in civil engineering from the college of applied science at Syracuse University.

The results are shown graphically on the accompanying charts, but an explanation will make a clearer understanding.

Letters were sent to 249 graduates, asking for statements of their annual incomes since graduation, and whether or not they were engaged in engineering work. To facilitate replying a blank form was enclosed on which the information asked for could be noted. These blanks were numbered so that the replies could be checked up with a mailing list and they were not to be signed.

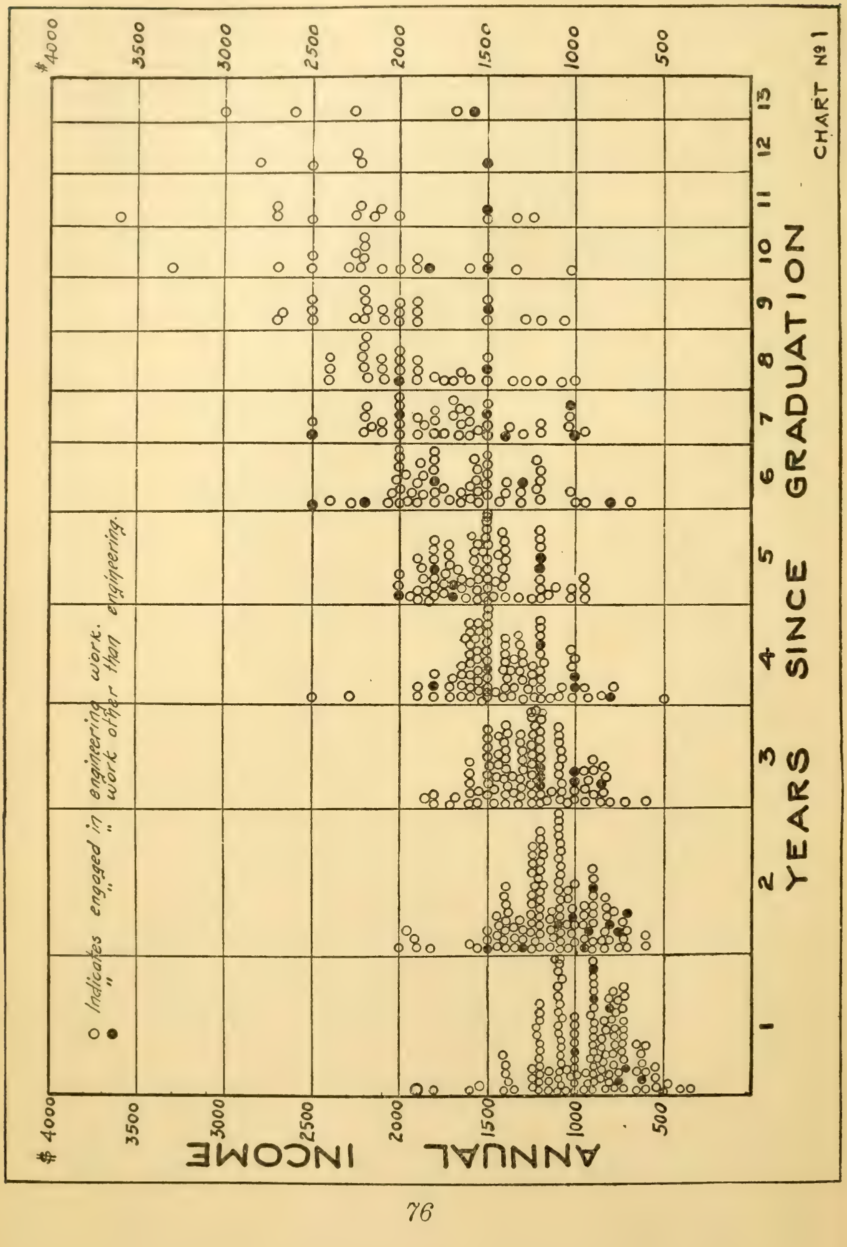
The letter of request stated that the information was wanted for a study of this sort and it was promised that answers would be regarded as confidential as far as the individual was concerned.

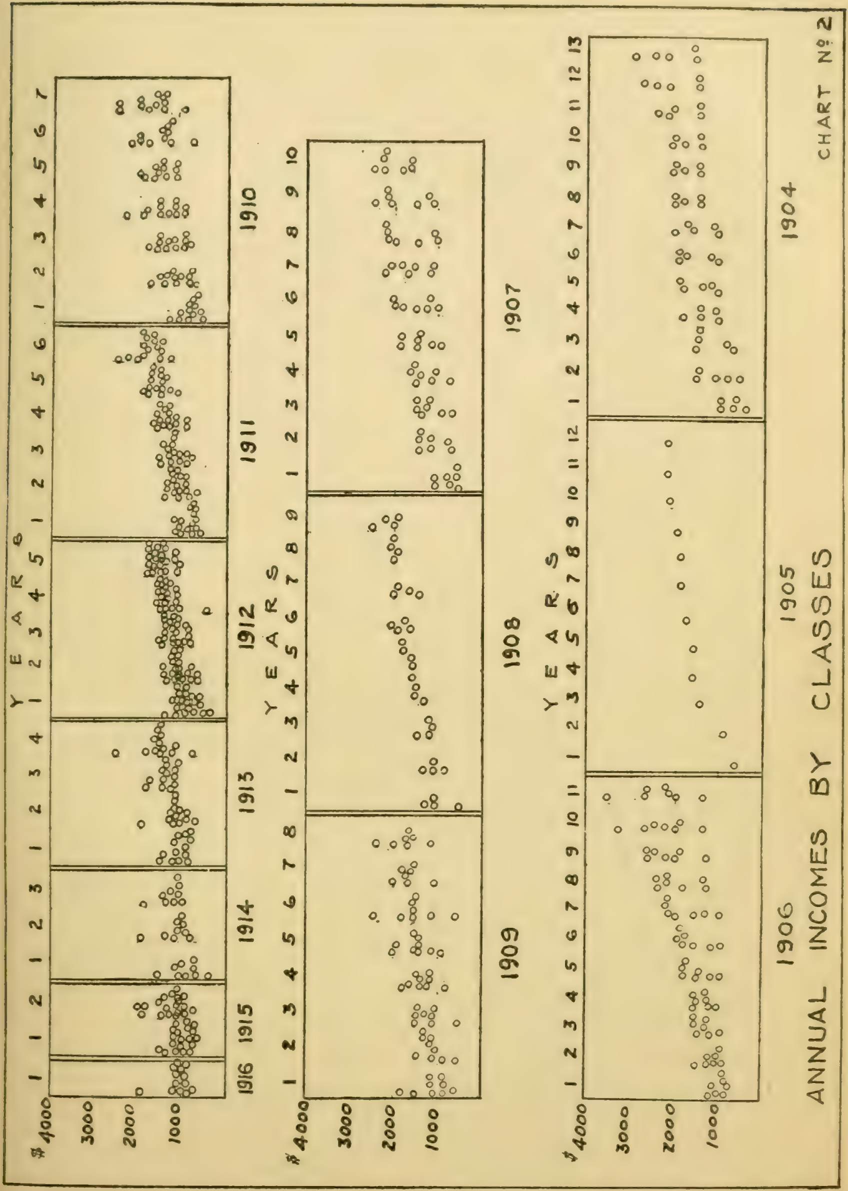
The college of applied science was established in 1901 and the first graduating class in civil engineering was in the year 1902. No member of the 1902 class replied and as there were no graduates in civil engineering for 1903, this study is therefore limited to a period of 13 years and is based on 135 replies.

One hundred and thirty-seven answers were received. One reply, as explained later, is not included in the results, and one man reported that his employer did not wish him to furnish the information asked for.

Chart No. 1 shows replies as received. On this diagram the salaries of the 1916 men appear only in the first column, those of the 1915 men in the first and second columns, etc. This

EARNINGS OF CIVIL ENGINEERING GRADUATES.




ANNUAL INCOMES BY CLASSES
CHART No. 2
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
YEARS
$4000
3000
2000
1000

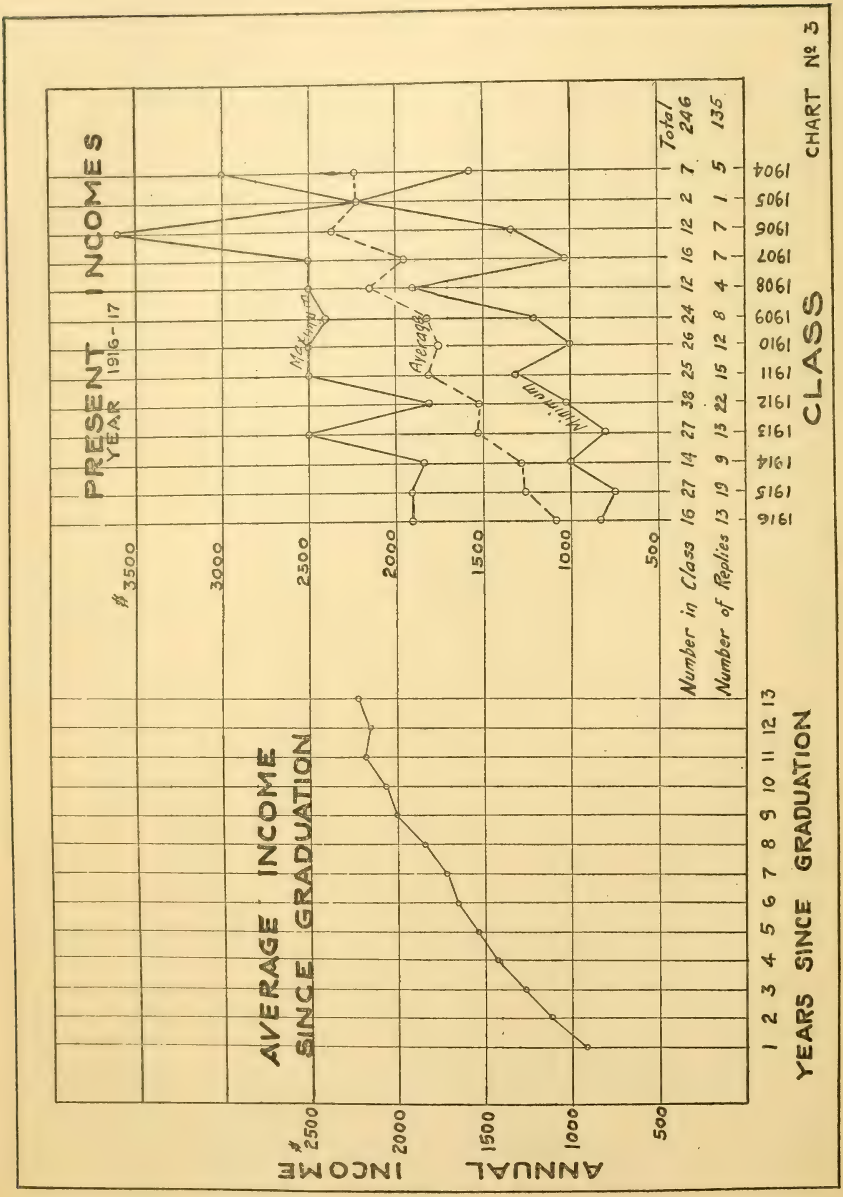

PRESENT INCOMES
YEAR 1916-17
Maximum
Average
Minimum
$3500
3000
2500
2000
1500
1000
500
Number in Class 16 27 14 27 38 25 26 24 12 16 12 2 7 Total 246
Number of Replies 13 19 9 13 22 15 12 8 4 7 7 1 5 135
1916 1915 1914 1913 1912 1911 1910 1909 1908 1907 1906 1905 1904
CLASS
AVERAGE INCOME SINCE GRADUATION
ANNUAL INCOME
$2500
2000
1500
1000
500
1 2 3 4 5 6 7 8 9 10 11 12 13
YEARS SINCE GRADUATION
CHART Nº 3

chart also differentiates between the men who are engaged in engineering work and those who are not.

It was hoped that sufficient information would be available to make a comparison between these two classifications as well as the men who were elected to Tau Beta Pi Society (honorary engineering fraternity), but these attempts had to be abandoned on account of insufficient data.

On Chart No. 2 the record of each class by years since graduation is shown, and on Chart No. 3 is a summary of the results on charts Nos. 1 and 2.

The writer considered showing a ''middle'' as well as an ''average'' income curve, but felt that an inspection of the charts showed this to be unnecessary. By ''middle'' income is meant the income of which there are just as many lower as higher. Had there been any extremely high salaries this would have been justified, as in that case the average salary would not be representative.

Partly for this reason and mainly because the graduate is a foreigner, engaged in work in his own country, the annual income of one of the men is not included in this report. It is, however, of interest to give the following information regarding him: present salary $10,000, years since graduation 5, average salary since graduation $7,600.

It should also in fairness be stated that in several cases the present rate of salary is substantially higher than that indicated by the last annual income. These are cases where men received increases during the year, but whose incomes as reported include actual yearly earnings.

A STUDY OF ENGINEERING ENROLLMENT.

BY CALVIN H. GROUCH,

Professor of Mechanical Engineering, University of North Dakota.

The growth of the engineering colleges at the University of North Dakota having been slow during the past few years, the writer decided in the fall of 1915 to ascertain, if possible, whether the condition was peculiar to North Dakota or was prevalent at other institutions and to decide if possible the cause for the same.

Information was obtained from a number of institutions with the understanding that it was not for the public but for home consumption. Several of those who furnished the information requested copies of the results of the investigation and a number suggested that they be published in the BULLETIN of the S. P. E. E. The latter were so numerous that it was decided to ask permission to publish the information sent and to secure additional data from other institutions, so that one might draw fairly accurate conclusions from a study of the same. Permission to publish the information was granted in most cases, but in several instances it was not, so that the information presented is not as complete or as representative as might be desired, but it covers a sufficient number of institutions in various parts of the country so that a study of the same will enable one to draw fairly accurate conclusions.

The information received consisted of presidents' annual reports, catalogues, alumni directories and tabulated data which had been compiled by the different institutions for specific purposes so that the information received was varied in character and much of it not germane to the subject being investigated, so that it was no small task to select the information desired. While much of that received was interesting and would be useful in helping one arrive at conclusions it was so different from that asked for and from that sent by other institutions that it was impossible to reduce it to a suitable classification and it could not be used without much explanation and has therefore not been included in the data presented. Only such data has been used in plotting the curves which follow, as was capable of being reduced to one of three classifications.

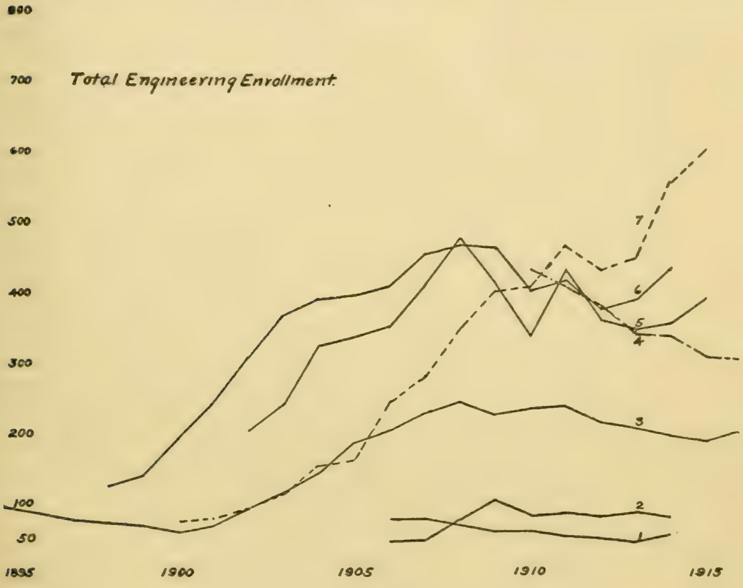


Fig. 1.

The data collected is represented by three groups of curves showing Total Engineering Enrollment, Total Engineering Graduates and Total M.E., E.E. and C.E. Graduates. It should be noted that even this classification does an injustice to some institutions, for in some institutions students specializing in chemistry are evidently classified as engineering students while in others they are not, so it was difficult if not impossible to reduce the data to proper bases for comparison. The information relative to the four- and five-year courses at certain institutions was of such a nature that it might easily be misinterpreted and has purposely been omitted. The data from which curves have been plotted is supposed to cover only the four-year courses, though it is barely possible that in one or two instances fifth-year or graduate students have been included unintentionally, but even though this has occurred the results will not be seriously effected.

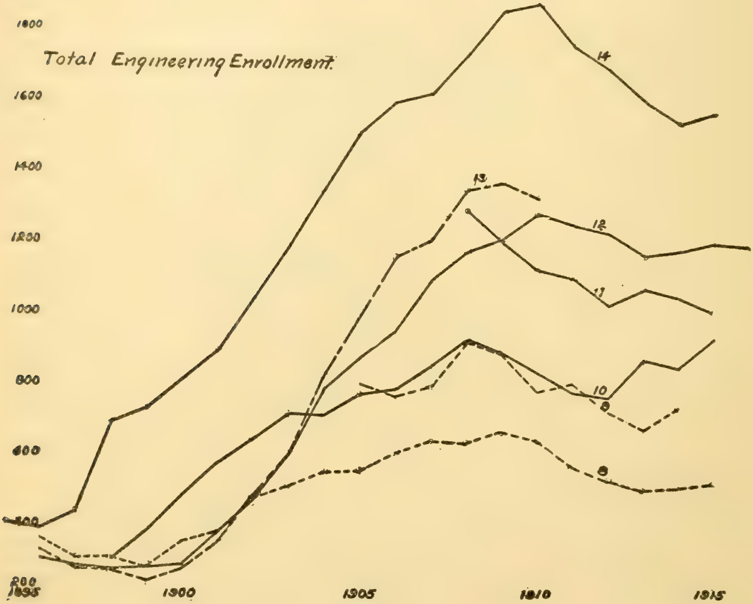


FIG. 2.

It was at first planned to plot curves showing the number of students enrolled in all of the various branches of engineering, but this was impossible because at several institutions the freshmen do not specify the line of engineering they purpose to follow and are classified as freshmen engineers with no reference to any particular branch of engineering.

In determining the total engineering graduates for certain institutions, the graduates from the course in architecture have been included as engineers, although the data examined did not so classify them. This was done so as to make results comparable, because at several institutions architecture is given in the engineering college and the data sent included statistics covering both students in architecture and engineering and it was impossible to separate them.

In writing the various institutions for information, the suggestion was made that any explanation which might be made for sudden changes in the enrollment would be welcome and would be useful in helping one interpret the results as the change might be due to local rather than to widespread causes, but with few exceptions the data was submitted without comments.

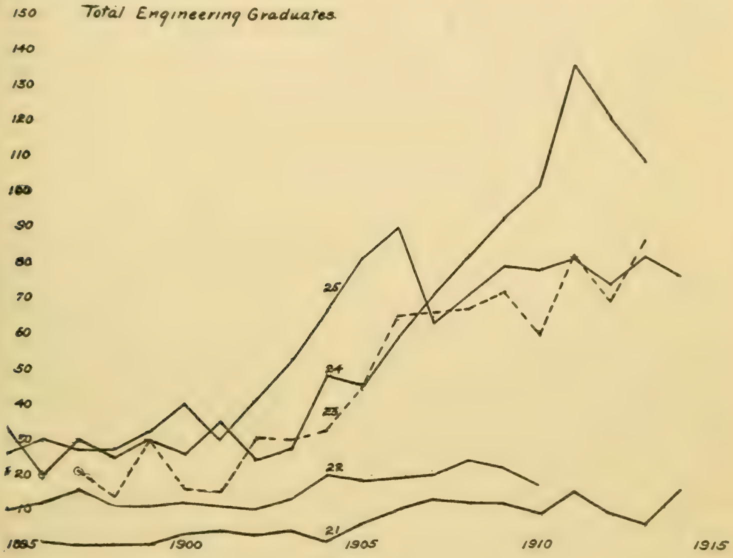


FIG. 3.

While sudden changes in certain curves may perhaps be explained by local conditions, one is impressed, from a study of the curves, by the fact that since about 1908 there has been, with here and there an exception, a marked decline in the engineering enrollments at a number of institutions.

It would be both interesting and instructive if tables or curves were available, showing the enrollments not only in the various lines of engineering, but in the various other professions at all the leading institutions. The author has compiled several of such tables for different institutions, but will include only one, as it shows in a pronounced manner what is taking place to a more or less degree at many other institutions. A study of the curves will show that this condition is not peculiar to any one institution.

The following table shows some of the statistics selected from the data concerning one institution.

TOTAL ENROLLMENT.

	Year.							
	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Agriculture	156	199	256	319	378	515	577	608
Science	118	119	153	175	191	218	248	283
Chemical engineering	51	67	79	74	102	130	138	168
Mechanical engineering	373	346	310	342	338	365	348	343
Electrical engineering	432	408	401	375	351	345	321	303
Civil engineering	441	385	346	309	245	232	240	192
Total M.E., E.E. and C.E. graduates	258	225	219	217	183	165	174	150

It will be noted that at this institution the enrollment in agriculture during the period from 1908–1915 has quadrupled, the enrollment in science has more than doubled, that in chemical engineering has trebled and that in mechanical, electrical and civil engineering has decreased.

That the increased interest in agriculture is not confined to this one state or institution is shown by the enrollment at Cornell University where between the years 1895 and 1902 the enrollment in agriculture increased from 45 to 92, when it began to increase rapidly and in 1915 had increased to 1,670. In other words during the last thirteen years it has increased nearly eighteen fold, a most remarkable growth showing a decided awakening to, and an appreciation of, the value of scientific agriculture. The enrollment in engineering and architecture at Cornell increased from 1,056 to 1,885 between the years 1902 and 1910 and then declined to 1,570 in 1915.

An examination of the data from a number of other institutions indicates that there has been a marked falling off in the enrollments in the older lines of engineering such as mechanical, electrical and civil engineering and a large increase in the enrollments in agriculture, chemical engineering or applied chemistry, sanitary engineering, science and architecture. To form a correct opinion as to what is taking place, one should not only have information similar to that here presented but he should have data showing the enrollments in all of the other four-year courses in the leading institutions so as to determine what proportion the engineering students form of the whole student body. Curves showing this information in percentages of the total student enrollment would probably indicate still sharper declines in the engineering enrollments at many insti-

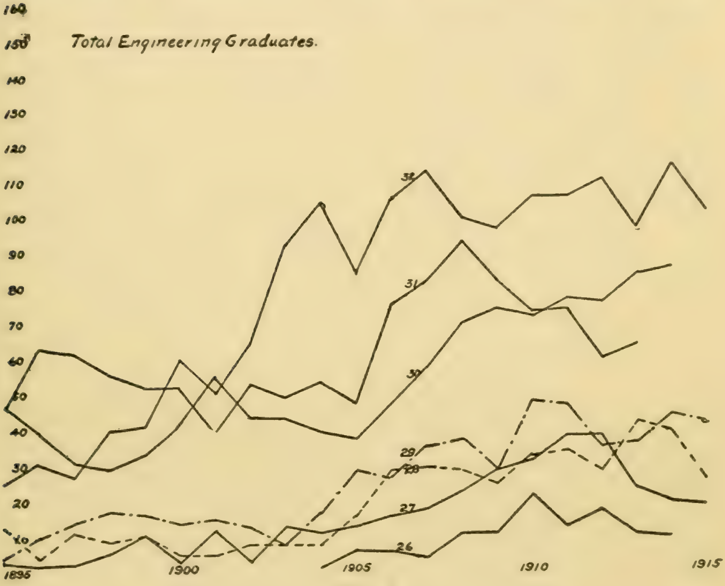


FIG. 4.

tutions than are indicated by the curves here presented as the total enrollment at most of the institutions has doubtless increased during the period investigated.

It is not the purpose of the author to draw conclusions but to place before the reader some of the results of his investigation and allow the reader to draw his own conclusions. The author regrets that the information is so incomplete, but, as previously stated, he was unable to obtain permission to publish the data concerning several institutions which would have enabled him to have made a much better presentation of the subject. The data from one institution showed with one exception a decline in the number of entering engineers since 1908, which was attributed to the fact that enlarged attendance was not encouraged for financial reasons. This decline continued until after the tuition had been increased, thus enabling expansion when the curve shows an upward tendency.

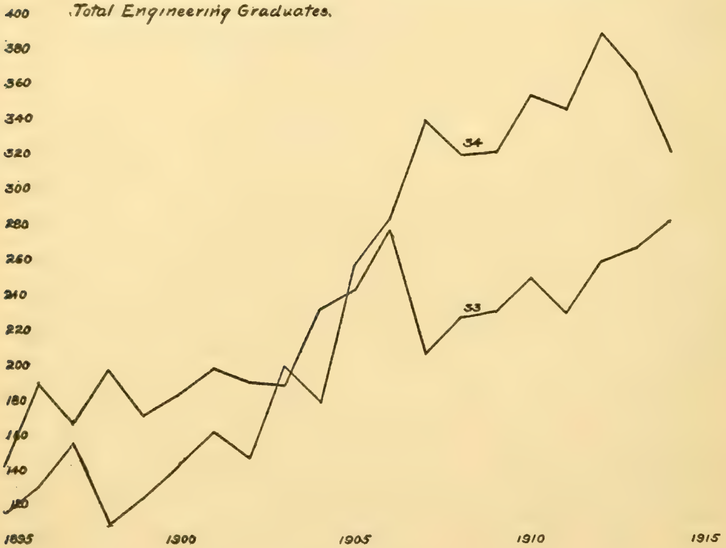


FIG. 5.

In one other university the college of engineering was reorganized in 1912 and an increased enrollment followed. At another institution, the decline in the engineering enrollment was attributed to increase in entrance requirements.

At the University of North Dakota the entrance requirements of all colleges of the university have for years called for fifteen units. To enter the liberal arts or teachers colleges a student must offer four constants consisting of three years of English and one of mathematics, the remaining eleven units being electives which may be offered from certain groups, while a student entering one of the engineering schools in the past must have offered ten constants and five electives at entrance. This number of constants required for entrance to the engineering schools was reduced in 1916 by transferring two years of foreign language and physics from the list of constants to

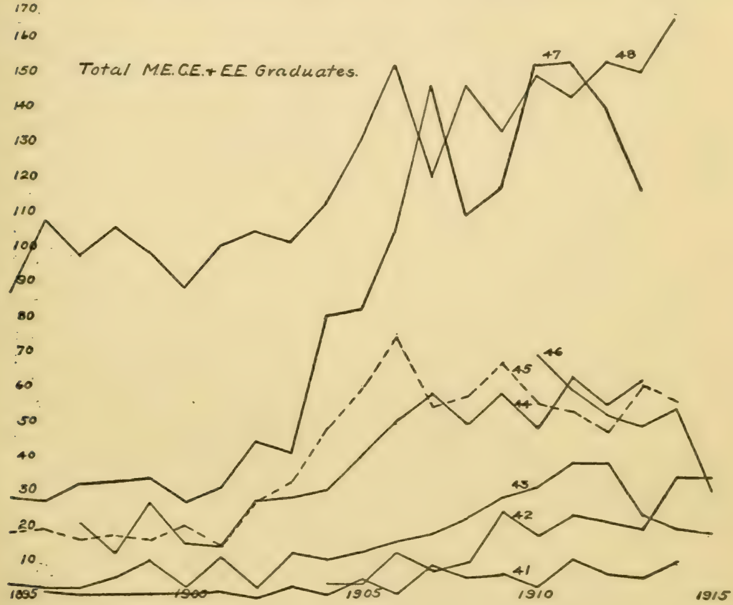


FIG. 6.

the elective list and at the same time provision was made in the college course for the foreign languages. Fifteen units are required as heretofore but the reduction in the number of constants and a corresponding enlargement of the elective list will doubtless have a marked effect upon the engineering enrollment at this institution.

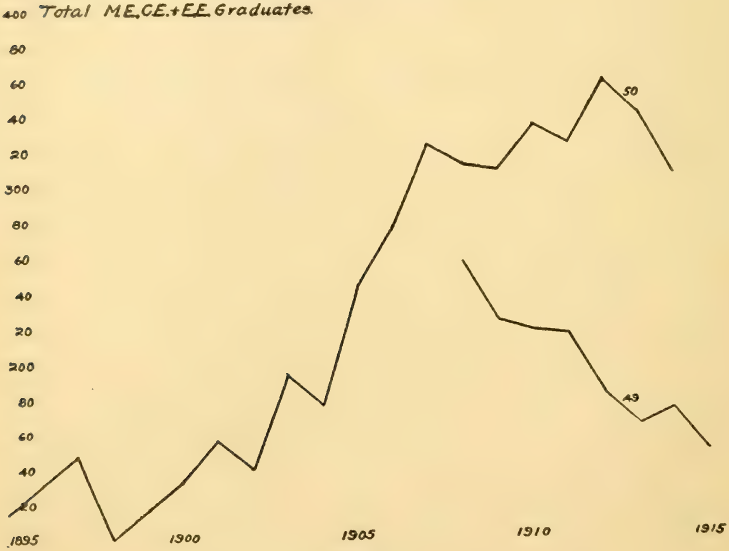


Fig. 7.

The following explanatory statements give the names of the institutions represented by the various curves and the classes of students included in the statistics from which the curves have been plotted.

The abbreviations used are as follows:

M.E. for Mechanical Engineering,
E.E. for Electrical Engineering,
C.E. for Civil Engineering,
Chem.Eng. for Chemical Engineering,
Mi.Eng. for Mining Engineering,

Sanit. for Sanitary Engineering,
Arch. for Architecture,
Mar.E. for Marine Engineering,
Chem. for Chemistry.

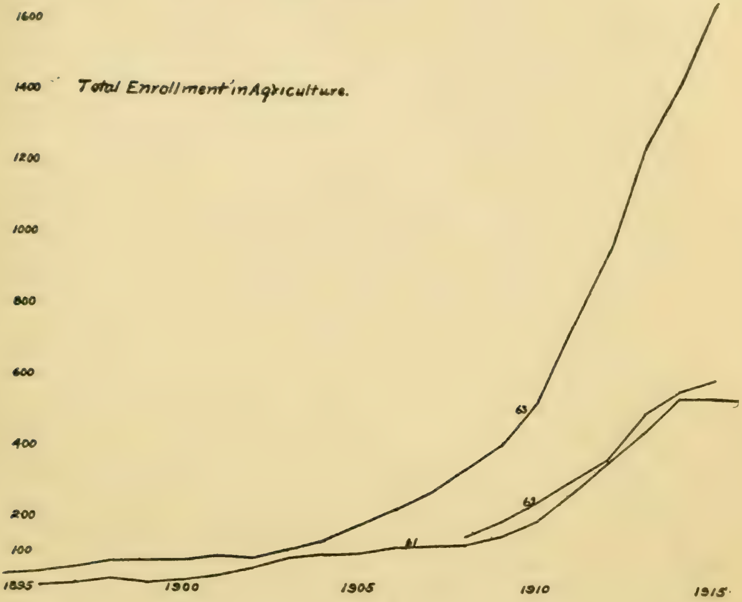


FIG. 8.

TOTAL ENGINEERING ENROLLMENTS.

Curve No.	Name of Institution.	Classes of Students Represented.
1.	University of Montana	M.E., E.E. and C.E.
2.	University of North Dakota..	M.E., E.E., C.E. and Mi.Eng.
3.	Tufts College	M.E., E.E., C.E. and Chem.E.
4.	University of Nebraska	M.E., E.E., C.E., Sanit.Eng., Mi.Eng. and Metallurgical Eng.
5.	University of Kansas	M.E., E.E., C.E., Mi.Eng., Chem., Saint. and Arch.
6.	University of Minnesota	M.E., E.E. and C.E.
7.	University of Washington ...	M.E., E.E., C.E. and Chem.Eng.
8.	Lehigh University	M.E., E.E., C.E., Chem.Eng., Electro Metallurgical, Metallurgical Eng., Mi.Eng. and Arch.

9.	University of Wisconsin	M.E., E.E., C.E. and Mi.Eng.
10.	Ohio State University	M.E., E.E., C.E., Mi.Eng., Arch., Clay working Ceramics, Chem., Industrial Arts.
11.	Purdue University	M.E., E.E., C.E. and Chem.Eng.
12.	University of Illinois	M.E., E.E., C.E., Mi.Eng., Arch. and others.
13.	University of Michigan	M.E. E.E., C.E., Chem.Eng., Mar.E. and Arch.
14.	Cornell University	M.E., E.E., C.E. and Arch.

Total Engineering Graduates.

21.	University of Idaho	M.E., E.E., C.E., Chem.Eng. and Mi.Eng.
22.	University of Pittsburgh	M.E., E.E., C.E., Chem.Eng. and Sanit.
23.	Armour Institute of Technology	M.E., E.E., C.E., Chem.Eng., Fire Protection Eng. and Industrial Arts.
24.	University of Pennsylvania	M.E., E.E., C.E. and Chem.Eng.
25.	Case School of Applied Science	M.E., E.E., C.E., Mi.Eng., Chem.Eng., Physics and Arch.
26.	University of North Dakota	M.E., E.E., C.E. and Mi.Eng.
27.	Brown University	M.E., E.E. and C.E.
28.	Union College	B.E.
29.	Tufts College	M.E., E.E., C.E. and Chem.Eng.
30.	Worcester Polytechnic Institute	M.E., E.E., C.E., Chem.Eng. and General Science.
31.	Stevens Institute of Technology	M.E., E.E., C.E., Chem.Eng., Arch. and Physics.
32.	University of California	Chem.Mechanics and C.E.
33.	Massachusetts Institute of Technology	M.E., E.E., C.E., Arch., Chem.Eng., Sanit. and Mi.Eng.
34.	Cornell University	M.E., E.E., C.E. and Arch.

TOTAL M.E., E.E. AND C.E. GRADUATES.

Curve No.	
41.	University of Idaho.
42.	University of Washington.
43.	Brown University.
44.	Armour Institute of Technology.
45.	Case School of Applied Science.
46.	University of Nebraska.
47.	University of Illinois.
48.	Massachusetts Institute of Technology.
49.	Purdue University.
50.	Cornell University.

TOTAL ENROLLMENT IN AGRICULTURE.

Curve No.	
61.	University of California.
62.	Purdue University.
63.	Cornell University.

EDITORIAL.

The article by Sanford A. Moss, of the General Electric Company, in this number of ENGINEERING EDUCATION calls attention in a different way to the importance of reorganizing, to a certain extent, the courses in engineering so as to bring into the freshman and sophomore years some of the applications of engineering in such a way that the student will feel when he elects the engineering course, that he is studying engineering.

Mr. Moss shows that there is little actual contact with the sort of problems which practicing engineers must solve in designing, constructing and operating machinery. He calls attention to the fact that it is not now customary to give machine design, kinematics, mechanism, mechanical laboratory, and experimental engineering in the freshman year, but proposes that courses should be so arranged that this can be done. A study of the curricula of the engineering courses emphasizes the fact that there are many subjects, especially in experimental engineering, now given in the junior and senior years, which could be given to advantage to the student and to the courses in the freshman and sophomore years. It does not appear that it is necessary that students should have the whole, or even a large part of the theoretical work, before taking up some of the courses which deal essentially with the work which, as practicing engineers, they must do.

THE EXECUTIVE COMMITTEE HAS ADOPTED A RESOLUTION WHEREBY MEMBERS WHO HAVE ENTERED GOVERNMENT SERVICE ARE EXEMPT FROM DUES DURING THEIR PERIOD OF SERVICE. **TO SUSTAIN THIS ACTION ALL DUES MUST BE PAID IMMEDIATELY.**

PLEASE SEND CHECK TO W. O. WILEY, TREASURER, 432 FOURTH AVENUE, NEW YORK CITY.

COLLEGE NOTES.

University of Illinois.—The number of undergraduate students registered in the College of Engineering of the University of Illinois twelve days after the beginning of registration for the new year, is as follows:

Architecture	91
Architectural engineering	107
Ceramic engineering	22
Civil engineering	151
Electrical engineering	209
Mechanical engineering	217
Mining engineering	18
Municipal and sanitary engineering	11
Railway engineering	38
Total	864

The enrolment of students in the whole university, not including the College of Medicine, the College of Dentistry and the School of Pharmacy, which are located in Chicago, is as follows:

College of Agriculture	683
College of Commerce and Business Administration	554
College of Engineering	864
College of Law	34
College of Liberal Arts and Sciences	1,598
Library School	49
School of Music	92
Graduate School	266
Total	4,140

Kansas State Agricultural College.—C. F. Baker, A.B. University of Illinois, B.S. in Architecture and M.S. in Architecture Massachusetts Institute of Technology and for about ten years in architectural practice, has been appointed professor in charge of our department of architecture.

K. J. T. Ekblaw, M.E. Yale, B.S. and M.S. University of Illinois and recently with the Division of Rural Engineering of the Department of Agriculture, has been appointed professor of farm engineering.

J. D. Walters, for forty-one years professor of architecture at the Kansas State Agricultural College, has been made Professor Emeritus.

M. W. Furr, B.S. in C.E. Purdue University, and recently instructor in the State University of Iowa, has been appointed instructor in civil engineering.

Lafayette College.—As evidence of the cordial relation which exists between the French Embassy at Washington and Lafayette College, the greatest memorial to General LaFayette, General Vignal, Military Attache at the embassy, will make an address at the college on its Founders' Day, October 24. General Vignal is a colonel of engineering in the French Army and was very prominent in the battle of the Marne. It is very appropriate, therefore, that he should have elected as the subject of his address, "Science and Engineering in Modern Warfare." The college will confer on General Vignal the degree of doctor of engineering.

At a recital given by Professor Charles E. Knauss, of Philadelphia, the new organ in the Colton Memorial Chapel at Lafayette was dedicated last week. The organ is the gift of Mrs. J. Milton Colton, the donor of the chapel. The instrument was built by the Ernest M. Skinner Company, of Boston. It is a three manual organ with a total of fourteen hundred pipes.

The Pennsylvania State College.—Prof. E. D. Walker, head of the Department of Civil Engineering of the Pennsylvania State College, is captain in Company A, of the 5th regiment of Engineers, which left Pittsburgh about July 8 for foreign service.

Prof. Hugo Diemer, head of the Department of Industrial Engineering, has received a commission as major in the Ordnance Department. He is at present located at Lowell, Mass., in charge of the inspection of fire arms.

Other members of the faculty who are in military service are Mr. J. J. Light, of the Department of Mechanical Engineering, who has been commissioned a captain; Lieutenants Steel, Long and Bryans, of the Department of Civil Engineering, are on duty at various camps; Mr. Mills, of the Electrical Engineering Department, is in Washington on naval construction.

The School of Engineering has the largest freshman enrollment in its history, numbering 271 as compared to 210 at this time last year. The upper classes are from 50 to 75 per cent. of normal, due to the large number who volunteered last spring.

Ninety per cent. of the faculty of 70 in the School of Engineering were employed in government or industrial engineering service during the summer vacation.

Prof. E. N. Bates, of the Department of Mechanical Engineering, conducted investigations for the Department of Agriculture on the Pacific Coast.

Prof. R. B. Fehr was in the employ of the Bureau of Public Roads, Washington, D. C., investigating the subject of soil pressures.

BOOK REVIEWS.

Electrical Engineering—Advanced Course. By ERNEST JULIUS BERG, Sc.D., Professor of Electrical Engineering, Union College. Author of "Electrical Engineering—First Course." McGraw-Hill Book Co. 1917. 6 × 9. 330 pages, 163 illustrations. Cloth. $3.50 net.

Abstracts of a series of lectures given by the author arranged in teachable form, especially adapted to graduate students in electrical engineering. Abnormal or transient conditions in electric circuits are treated mathematically in a manner thoroughly intelligible to the technical graduate. A really advanced book on practical electrical engineering problems.

H. E. D.

Applied Mechanics. By Alfred P. Poorman, A.B. and C.E., Assistant Professor of Applied Mechanics, Purdue University. McGraw-Hill Book Co. 1917. 6 × 8¼. 240 pages. $2.00.

This is a book of 240 pages evidently designed as a text for a class which completes its study of analytic mechanics in a single semester. It covers the usual ground clearly, concisely, and completely. The author develops his subject by a well-written discussion followed by one or two typical examples worked out as illustrations. These are followed by a well chosen set of problems. Many sets of general problems are also included.

W. R. W.

In Re Theoretical Depreciation. By J. E. Allison, St. Louis, Mo. A paper presented for the consideration of the Public Service Commission for the First District of the State of New York by the Consolidated Gas Company.

This is a very able presentation of the subject of depreciation. This much discussed subject is brought out in detail by a thorough discussion and analysis of the paper presented by Dr. Weber, of the Public Service Commission of the First District of the State of New York. This report should be read by all those interested in depreciation of operation in any form.

H. E. D.

BULLETIN

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SOME FACTORS IN STUDENT SCHOLARSHIP.

BY V. KARAPETOFF,

Professor of Electrical Engineering, Cornell University.

A faculty committee on recognition of student scholarship was formed in Cornell University in 1916, and members of the faculty were asked to contribute their views and recommendations for discussion.

The following remarks were written in response to this invitation, and were subsequently edited for this article with the omission of purely local matters.

That which Cornell University has done for its own students might be well done by the Society for the Promotion of Engineering Education for all technical colleges. The first step would be the appointment of a committee to consider measures and methods of instruction that best encourage and stimulate student scholarship. A suitable name would be "Committee on Methods of Instruction."

The following remarks may give some idea of the character and scope of work of such a committee.

Standardization of Courses, without adaptation to individual needs or fancies, is detrimental to interest and initiative. By tightening the discipline more work and better work can be ground out of a student, but this is far from true scholarship inspired by genuine interest. For average or indifferent scholars standardization may be good, but in this mass of mediocrity the gifted minority is drowned. Pick out gifted scholars in the Freshman year and guide them separately as honor students. The effect will be good for them, and will stimulate the big inert body of "barely passings."

Utilitarian View on College Education, with a degree and a job as the only ends in view, is detrimental to high scholarship. One remedy is to provide several grades of degrees, or to number diplomas each year in the order of their holders' scholarship. At West Point and at Annapolis there is a distinct advantage in having high marks. In the C.E. College in Petrograd from which I graduated one had to have at least a grade of 80 per cent. in all important subjects throughout the five years in order to get a first-degree diploma. The rest got a second degree diploma, which involved a distinct disadvantage in rank in governmental service. The Russian universities used to grant three kinds of baccalaureate degrees, according to scholarship: candidate of rights, true student and lover of enlightenment. Only the first named degree qualified for government service. At graduation exercises the name of the best scholar used to be put on a marble tablet in golden letters and placed in the hall of honor. This distinction was always coveted by several men throughout the five years of the course. I believe that two grades of degrees are perfectly feasible in this country, for example calling one degree M.E. "with honor." With the democratic tendencies of the times, when every Tom, Dick and Harry enters a university, it is necessary to keep up the scholarship of a majority by a rigid discipline, and to have a tangible goal for the capable and ambitious minority, say a different shade sheepskin. True scholars will take care of themselves, and we shall have them as long as we have faculty members who themselves are true scholars and investigators.

Ignorance of Psychology of Study.—It is a matter of common knowledge that a student wastes considerable time because he does not know how to study, and how to take care of his mind and body. The psychological process of assimilation of knowledge is one of the subtlest known, and who trains the student in it? Who tells him of introspection, of psychology of attention, of first and second fatigue, of the plateau of effort, of associative memory, of superposition of starting periods, and of such other useful things that permit one to achieve much in a short time? Many persons have said to me that they fail to see how I find time for this or that; but in the twelve years of my teaching career in this country only one faculty member came to ask me about my methods of study. He never came a second time either, because he thought that to use my methods would be like wearing several steel braces. And yet I find my yoke easy, because I learned the systematic efficient way of living and working while I was young. Let our instructors learn how to study, and let them teach Freshmen, in application to some simple subject, how to remember a given fact or law, how to assimilate a relationship, how to acquire manual skill, how to spend an evening in study, etc. Even mathematics and mechanics can wait half a year for such an important discipline, one that will save each student many a weary hour throughout his life. This is one reason why each instructor should be a student of some subject, and an investigator. He will know then what the process of assimilation is, and what miracles can be achieved once an intense interest has been aroused in the student.

Physical, Volitional and Emotional Activities.—A normal young man needs all these, but most colleges do not properly regulate them, except perhaps for military drill and athletics. Self-supporting students who wait on table or tend furnaces get physically exhausted, while rich fraternity boys ride in a street car a distance of a few blocks. Who can overestimate the importance of a properly trained will in a college graduate? Is it more important for the country that he should know how to determine the size of a shaft or of a steam cylinder, or that he should stay on the straight path in the hour of temptation, and be able to guide others? There is no study more difficult than the training of the will, but when the will is under control all other studies are open to the man.

Co-operative Study.—It has been well said: "School is not preparation for life, it is life itself." We do not care to make it an imperfect life of laziness and cruelty, of greed and deceit, but let us give our students at least a glimpse of a better life of which we dream and which we hope for. Every community is organized for some purpose; why not organize a community for the purpose of study? Then the students working to maintain and to improve this community will get the necessary volitional and emotional training. As long as they remain individual "visitors" to the college, members of an audience, they do not exercise the most important function of the civilized man, the ability to work in a community. Every difficult problem in mechanics or in electricity should be a community problem for the class, and not an individual problem for Mr. Jones. Only then will scholastic achievement be held in high esteem, and a lazy student will be ostracised as a useless member of the community. This will also give a splendid training for leaders of different kinds, mental, volitional and emotional. But of course, as long as we have to "cover" a certain number of pages in a certain book, we cannot stop to discuss an interesting problem when a previously mimeographed schedule calls for the next chapter.

Outside Work.—A considerable number of students do outside work, either to earn their living or as a voluntary avocation. Personal interviews elicit a surprising variety of such occupations, most of which are detrimental to true scholarship. The university is almost powerless to provide for impecunious students, unless it takes a radical step, and requires more fortunate students to contribute their work for the support of less fortunate one. For example, a student usually has to put in four hours a day seven days a week waiting on table for his board; this is usually to the detriment of his studies. Two other students receive all their sustenance from home, and waste some of their leisure time. Now suppose the university should encourage or even require each of these two students to wait on table for one meal a day, and thus enable their struggling comrade to have his three meals though waiting on table for one meal only. The university should take a lead in this "help your brother" movement, and I feel confident that a great deal of moral good could be accomplished both for those helping and those helped.

From Practice to Theory.—A number of freshmen and sophomores get discouraged or are dropped on account of mathematics, physics and mechanics; others manage to squeeze through, but retain no love for these subjects, and acquire no ability whatever in using them. The order of courses should be reversed, concrete facts as used in engineering practice should be taught first and then generalized into semi-abstract statements. Of course, this would mean a radical change in the arrangement and character of studies, but it would stimulate interest early in the course, and will help to weed out men without engineering talent, rather than those who are too immature for calculus. Moreover, a reasonable time should be allowed in the freshman year for descriptive and experimental lectures in various branches of engineering (orientation courses) so that the student could select the one for which he is best fit. Maladjustment is undoubtedly a serious cause of poor scholarship.*

The Faculty.—How much blame for poor scholarship among the students is due the faculty, and especially to young instructors? A mature experienced teacher and investigator presents a topic from several points of view, at least one of which should appeal to the student. He modifies his statements to suit the class, he alludes to further developments and applications of the topic under discussion, brings in parallels and analogies, and inspires the students with the mastery of his subject. A young instructor usually knows little beyond the text book, holds recitations on the same topic, sometimes a dozen times a week in sections, requires precise knowledge of certain statements and problems in the book, and mostly fails to inspire or even to interest his students. A considerable proportion of young instructors give the course for the first time, and really do not know many essential points until they get to them. These ''non-commissioned'' officers of instruction are a great problem in a large college, and it is time to ask ourselves in all earnestness if we have not gone too far in breaking up courses into recitations, and converting our mature teachers into office managers? Should we not go back, at least in part, to lectures given by mature professors in larger groups, with frequent written examinations, the papers to be corrected by younger instructors?

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* For further details of this so-called *concentric* method of education see the author's paper in the PROCEEDINGS of this Society, Vol. 16 (1908), p. 258.

Small Improvements and Radical Changes.—Some improvement in scholarship can be achieved by numerous small changes, such as stricter discipline, better books and schedules, higher grade teachers, prizes, etc. All these things ought to be done as opportunities present themselves. On the other hand, a few radical changes, such as are indicated above, should also be seriously considered. They may seem at first impractical, but they are based upon sound human psychology, and as such ought to refresh the atmosphere and bring into play forces within students that are at present dormant. Every reform at a certain stage is considered impractical—the democratic form of government, the freedom of religion, the abolition of monarchical government, of nobility and of servitude, all these were held to be visionary, and yet they are among the most precious and most practical achievements of civilization.

A STUDY IN CURRICULA.

BY STEWART L. MacDONALD,

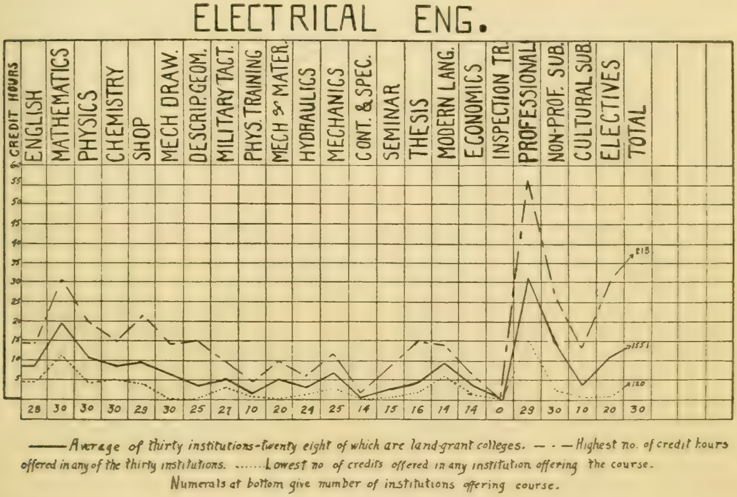
Professor of Mathematics, The Colorado State Agricultural College.

Some months ago at the Colorado Agricultural College a committee of the faculty undertook a study of the curriculum of that institution in view of making such changes as might seem advisable. One phase of the work of the committee comprised a survey of the courses of study of other similar institutions. Correspondence with more than forty of these institutions was carried on and a study made of their most recent catalogues.

The accompanying chart, which is an attempt at analysis of the courses in electrical engineering, is only one of several such charts which were worked out. While the chart, it is believed, is self-explanatory, yet some explanation may be helpful. For example, the first item on the left is that of English. The number twenty-eight (28) at the bottom indicates that out of a total of thirty institutions investigated, twenty-eight (28) were teaching English and that the maximum credit hours given this subject in any of the twenty-eight (28) institutions, as indicated by the upper dotted line, is fourteen (14); the minimum as indicated by the lower dotted line is four (4), while the average for the twenty-eight (28) is eight (8).

The unit used by the committee is the so-called credit hour. This unit is the one most commonly used by the institutions studied. A credit hour for a student may be defined to be one hour of recitation per week throughout one semester, which recitation requires on the average from one and one half to two and one half hours of outside preparation. For instance if a subject is scheduled for five recitation hours per week for one semester, and requires outside preparation as above stated, five credit hours will be the measure of credit in this subject. The committee went on the assumption that two laboratory hours, where outside preparation is required, is the equivalent of one hour of recitation, and where no outside preparation is required, three hours of laboratory shall be reckoned as an equivalent of one recitation.

Anyone who is at all conversant with the situation will fully realize the enormity of the task of working out this chart, simply for the reason that there is so little uniformity of procedure in this regard even among institutions of the same class. The problem is still further complicated by the woeful lack of a uniform technique. Each of a dozen institutions will be teaching what is essentially the same subject, probably using the same text-book, each under a different name. While it is



ELECTRICAL ENGINEERING.

—Average of thirty institutions, twenty-eight of which are land-grant colleges. —.— Highest number of credit hours offered in any of the thirty institutions. ......Lowest number of credits offered in any institution offering the course. Numerals at bottom give number of institutions offering course.

not the primary purpose of this article to argue in favor of uniformity and standardization, yet the present situation in this regard is almost prohibitive of any intelligent comparison of the curricula of American institutions of learning.

It will be understood that under *professional* is grouped a large variety of subjects which bear directly upon the subject of electrical engineering and too numerous to tabulate individually. The distinction between the purely cultural and non-professional subjects seems justifiable on the grounds that such subjects as surveying, while not regarded as cultural, are non-professional to the electrical engineer, while such a subject as literature would be purely cultural.

ELECTRICAL ENGINEERING IN AGRICULTURAL COLLEGES.

BY A. C. STEVENS,

Instructor in Electrical Engineering, Cornell University.

Within the last decade the science of agriculture has taken the place of old-time farming and our agricultural colleges have experienced the growth which not so long ago placed the engineering schools in the forefront of educational institutions. With the war has come the scarcity of labor and farmers everywhere are being forced to pay almost prohibitive prices for what little help is available. This is accelerating the natural increase in the use of labor-saving devices, with the result that the work of the rural engineering departments in our colleges is being accorded the appreciation which in many cases had been withheld.

Those who have followed this trend in agricultural progress a little farther have noticed that electricity is playing an increasingly important part in this development. This is true in spite of the fact that electrical education is not on a par with that of other branches of rural engineering.

In too many agricultural schools the student's knowledge of electricity begins and ends with a course in physics in which Ohm's law means a dry cell, resistance box and a galvanometer. The practical application is later restricted to the use of dry cells for ignition purposes.*

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* A study of catalogues of forty or fifty agricultural colleges in the country shows that in no case is a special course in electricity required. Some colleges give courses in rural engineering or farm mechanics in which electrical applications may have a small part, while others depend upon laboratory physics for the final work in practical electricity. Most colleges allow certain credit for elective work but the writer's experience at Cornell has been that a negligible percentage of the students elect work in electrical engineering. This may be due to the fact that the

Two incidents in the writer's experience come to mind which illustrate the lack of fundamental appreciation of electrical laws by college students who have had nothing but a course in physics to help them. In one case a junior, home for vacation, attempted to fix the door-bell which had been out of order for some time and after a search there were revealed two Leclanché cells in the darkest corner of the cellar. These were brought out, the solution renewed and the batteries returned, yet the bell would not ring. It took an electrician from one of the local hardware stores to explain that the wires had not been reconnected to the cells.

In the other case, a student had been given the task of changing the wiring in one of the college laboratories and after completing it decided that the ends of the two wires of the branch circuits did not look well so he carefully spliced and taped them. The lead wires were long and the regulation of the circuit poor so the fuses did not blow when the main switch was closed. It is not hard, however, to imagine the chagrin of the student on finding his wires gradually sagging, then turning dark and finally giving off volumes of dense black smoke.

While these may not be typical of the acts of college men when in search of electrical experiences, yet they indicate that electrical training does not always give the student the power to visualize the electrical action, or as some one recently expressed it, "The simple electrical laws are not a part of themselves." This condition is perhaps natural since the actual physical and visual contact which makes men so familiar with

need of the subject is not emphasized by the faculty and that the elective work given under other departments is not correlated with the prescribed agricultural course.

It is often difficult to decide from catalogues what is really covered in a certain course—so little information is given. Even the general heading may be misleading, as for instance, when courses 1*a* and 1*b* in mechanical engineering are found to be freehand drawing and carpentering respectively.

mechanical transformations of power are lacking in the case of the study of electricity.

To fit the potential farmer for intelligent use of electrical apparatus it is necessary for him to be able to handle power circuits. The experience of closing a switch on a complicated wiring job, without blowing a fuse, is one which is most helpful in instilling confidence as to one's ability to connect up and operate the ordinary electrical machinery.

Under these circumstances—with the electrical age in agriculture already at hand—it is essential that plenty of time be given to electrical study in agricultural schools. Without doubt the course for agricultural students should differ materially from that designed for engineers and would be based upon previous training, but above all it should leave a man with the feeling that he has made certain fundamental electrical principles part of his mental equipment and that he can intelligently decide such questions as he may meet concerning electrical apparatus.

No intention is here entertained of outlining such a course, yet some of the questions confronting the farmer which emphasize the importance of this training will be touched upon. In connection with an electrical exhibit recently held at Cornell during Farmer's Week, the writer had an opportunity to meet farmers from all over the state and learn something of their electrical problems. What impressed him most was, possibly, the lack of ability to ask pertinent questions about electric machinery. This is not surprising, yet the fact has an important bearing, for it means that the average farmer may be at the mercy of any electrical salesman who can talk convincingly about his goods. Even truths may be so clothed as to conceal facts as well as to reveal them.

The question as to which was the best of several small lighting plants on exhibition was the one most often asked. One was a 32-volt storage battery outfit with unit power plant consisting of a gasolene engine direct connected to the generator, another was a similar outfit with belt driven generator, while a third consisted of a small rotary slide valve gasolene engine, direct connected to a 110-volt generator. This last set was for use without storage battery, the engine being designed to run continuously when current was desired.

It is easy to smile at the question and to quote to oneself, ''Fools rush in where angels fear to tread,'' yet the illustration brings out the point clearly. To answer the question by saying that they are all good does not satisfy the questioner. He wishes answers to many questions which he knows not how to ask. To give these answers one must know to what use the electricity is to be put—whether for lighting alone or for some power work—what the maximum demand for current will be, how far the current will have to be carried, whether or not battery charging can be done with an engine already owned and at the same time that power is demanded for other things.

Even with these things determined, the patient questioner may still not be given as definite an answer as he desires. A recommendation in favor of one outfit may be construed as due to inherent superiority rather than to the fact that it was representative of a type most nearly suited to a special need.

So many agricultural colleges receive support from the state through political bodies that great care and diplomacy must be used not to appear to favor any one company or manufacturer. The result too often follows that the farmer who wishes to know how best to invest his money in a lighting-plant is still undecided or discouraged and gladly accepts definite statements such as the first glib salesman makes. This all goes to show that something is needed to give the farmer the very elementary grasp of electrical principles that will enable him to use his own good judgment in such matters. Decision can not be made for him for obvious reasons, so he must be trained by the colleges either in regular undergraduate courses or through extension work carried on under the direction of the universities.

The importance of agriculture to America and to the world is too well appreciated to need argument. With farms in the

United States numbering about six and three quarters millions and having a value of seventy-five billions of dollars, no effort and expense is too great to help increase the acreage under cultivation or to increase the productiveness of land already cultivated. This will be brought about by labor-saving devices of all kinds—not by cheaper farm labor—and electricity must be the open sesame for much, not to say most, of this in the future.

For the benefit of those who are interested in following the recent electrical development a short list is added of articles on the subject to be found in the technical press.

Application of Electric Motors to Farm and Dairy Industry. *G. E. Review,* 1911, p. 12.
Electricity on the Farm. A. I. E. E. Pro., July, 1912.
Electricity in Agriculture. *G. E. Review,* 1915, p. 483.
Application of Electricity to Agricultural Purposes. *London Electrician,* June 23, 1916.
Electricity in Rural Communities. *Electrical Review,* March 4, 1916.
Installation of Farm Lighting Plants. *Electrical Review and Western Electrician,* December 2, 1916.

ON THE ENGINEERING CURRICULUM.

BY A. J. BECKER,

Professor of Applied Mathematics, University of North Dakota.

The numerous articles on engineering education that have appeared within the past few years show that there is a doubt concerning the effectiveness of the average engineering curriculum. The rapid progress of industry during the past decade has brought about much of this uncertainty, for the engineer today has before him a much broader and more intricate field than his fellow of fifteen years ago had. Has his preparation kept pace with the things that are expected of him? To what extent is it desirable that his preparation shall keep pace with them?

There can be but one answer to the second question, for in it are involved the reasons for the existence of the engineering colleges. Only in so far as the student is taught engineering principles and the results of engineering experience better and in less time than he could acquire them in practical work is an engineering college justified. In any professional training, it is the intention to give only the work that is most directly applicable to the practice of the profession and at the same time is fundamental or closely related to all its branches. The standard of measurement is relative values, unless there is some other criterion than utility. It has been urged that the cultural value of a course is sufficient to give it a place in the curriculum, but, while culture and the satisfaction of extra attainment should be prized, the real criterion is the fitting of the courses into a broad foundation upon which the engineering graduate must rear his superstructure. That which best fits him for his work,—not merely for the first few years, but for the later years as well—does not give him perverted ideas of his own ability, nor require too much adaptation on his part, should make up the curriculum. This is in great measure the justification of the large amount of prescribed work.

Engineering education is largely conservative, sometimes too much so, and the danger is that we cannot bring ourselves to discard a course that has been established for years. No matter how desirable or valuable a subject may be, the decision to keep it in the curriculum or to discard it, must depend upon the number of courses that can be given and upon the relative value of each. If we could but apply our tests rationally and then unhesitatingly, even though with regret, carry out the conclusions, we should have little difficulty in keeping pace with engineering requirements. To avoid personal bias, the engineer in practical work should be freely consulted. He is the employer of the graduate and knows the things which are of greatest value. New ideas are suggested frequently and we should be ever ready to make use of those that are worthy, either in whole or by adaptation, even though the introduction may cause the dropping of courses which we have hitherto considered necessary.

As the usefulness of the engineer broadens, we are met with an increasing insistance upon more fundamental preparation, courses that tend toward a greater unity, with emphasis upon the sciences, mechanics, economics, and above all the ability to think clearly and to *apply* principles. That is, a true engineering education rather than a collection of facts, which while they are accepted practice today may be antiquated tomorrow.

There are three things that attract attention when one studies the averaging engineering curriculum. These are modern or foreign languages, shopwork and specialized instruction in narrow fields. The present critical study of engineering education as evidenced by the studies of Dr. Mann and by his recent appointment by President MacLauren of Massachusetts Institute of Technology as chairman of a permanent committee on the engineering curriculum, give weight to the opinion that we are facing a situation in many ways similar to that faced by the Colleges of Liberal Arts when Greek and Latin were dropped as requirements for the B.A. degree. We are confronting new conditions which demand better and broader preparation; we are manifestly unwilling to adopt generally the five or six year course, so that the courses which have the least direct bearing and usefulness must yield their places, however hallowed by age and universal sanction, unless by rebuilding they can be made of far greater service.

Language study, modern or ancient, is an heirloom of the first engineering curriculum. Accepted then for reasons which do not hold now, it can show but little basis for retention. There is no intention here to discuss the cultural or disciplinary value of language study, but rather to pass these by as insufficient reasons for retention. Until we are prepared to discuss a course extending over more than four years, cultural studies must be left to the spare hours after graduation. As for the disciplinary value, any course whose principal claim to a place in the curriculum is disciplinary value, should be dropped at once and put in the list of preparatory studies. Inasmuch as language study requires considerable memory work, the sooner it is begun the better. If a modern language is needed to pursue the study of certain subjects, it should be required for admission as are algebra or English. This puts it in the high schools or even in the grades, where it properly belongs.

There are but few reasons that may be advanced in favor of the study of the languages. Briefly they are (1) that it improves the student's English, both through the closer analysis of grammar and through a better command of words derived from the other languages; (2) that it will save an engineer the humiliation of having to grovel before a foreign word or phrase when reading a paper or listening to one; (3) that the broader commercial relations between this country and the rest of the world demand ability to speak and write other languages and through the languages to obtain a sympathetic point of view and better understanding of the peoples with whom one is dealing.

The first two points (and nearly all the others that are urged in favor of language study in an engineering curriculum) will be met as well by an entrance requirement as by time spent during the undergraduate years. Furthermore, it would seem that the acknowledged need for better English can be met more efficiently by a study of English itself, rather than other languages. The latter logically demands at least the study of French and German, if not Latin and Greek, with a preference for the Latin and Greek. With reference to the third point, those who expect to take up foreign trade work or to work in foreign lands, are the exceptions, not the rule. Language study sufficient for such purposes requires longer time than one or two years and is therefore to be considered only in so far as it may be cared for by electives or extra work. The value of language study is undoubtedly real, but when compared with English, chemistry, geology, physics, or mechanics, surely no one can feel that it should displace any of these even in small part.

One manifestation of the opinion of men in the practice of engineering is given in the compilation of the replies to the questionnaire sent out to the members of the honorary society of Tau Beta Pi by Professor Higbie, its president. In the summary* of the replies to the question "If it be impossible, in the time available, to give all things that seem desirable, which in your opinion, can be sacrificed with least injury to the student?" we find the following:

"The order in which studies should be sacrificed for lack of time, seems to be about as follows: Foreign languages, shop work, special engineering subjects. . . . The belief seems practically unanimous that foreign languages should be the first to go by the board."

Again we read, "The judgment of a large majority of these

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* See also BULL. S. P. E. E., April 17, 1917, p. 498.

(the alumni) is that the study of foreign languages should not be required in colleges of engineering—certainly not in a four year training wherein even the essentials of engineering science must be treated too briefly. . . . It is quite generally conceded by those who advocate language study in the engineering college, that knowledge of foreign language is not ordinarily necessary for progress in engineering profession or in business,—in fact, that such knowledge is so infrequently called for that it is quite likely to be forgotten or to become virtually useless, unless practiced from some other motive than necessity.''

The case of shopwork is rather different. There is no thought of entirely omitting it from the curriculum but to sort out the best in the subject and give this more effectively. Practically all of us will agree that the old manual training idea in shopwork is dead or should be, that there is no place in the curriculum for the development of skilled mechanics. This is the work of the trade school. But the problems of shop management, duplicate manufacture and quantity production, routing, labor problems, what to expect of an operative, piece work and other things directly connected with machine operation, require attention. The contact with the men in the shops, or the field or the mine, can best be obtained by requiring all students to put in two vacations, preferably those preceding and following the junior year—in actual work which is approved by the dean of the college, who can be of great assistance in providing this work. This is an adaptation of the cooperative idea followed at the University of Cincinnati, similar to that in use at the University of Pittsburg. It has been the experience of many of us that students who have been out of college for some time come back with a more definite purpose and study with far greater effect than during their previous attendance. Something of the same effect would be observed if students spent their vacations in apprenticeship along the lines in which they are specifically interested. The time might even be extended to require one year to be spent in practical work before the senior year is begun. This may reduce the number of graduates slightly, but it would improve the interest in and efficiency of the work tremendously.

Some of the things ordinarily included as parts of shopwork should be given as parts of other courses. The remainder can be given in much less time than is now required, with less work in the actual manipulation of machines and more in lectures and recitations. Civil and chemical engineers accordingly should have no shopwork, mining engineers perhaps one semester in the treatment of metals, electrical engineers perhaps two semesters and mechanical engineers three semesters of two hours each, or, with the usual laboratory equivalent, one afternoon per week. This work need not all be given in the first two years, much of the time now given to shopwork could be employed to better advantage, especially if the contact with labor and the processes of industry are secured by requiring the student to take his place as one of the workers and get his knowledge by experience.

To avoid any possible misunderstanding, a definition of specialized engineering courses will be given before attempting any discussion. Such courses are those which belong to narrow fields, not those which are fundamental to either of the broad general divisions of engineering but which are possibly out of place in others. Thermodynamics or ore treatment are by no means specialized courses. In many institutions men are specialists in a particular field and feel called upon to offer courses in these specialties. The work of the students in these courses must be superficial, for they lack the experience necessary to understand the subject properly. Heating and ventilating, design of cantilever and suspension bridges, design of high office buildings, power plants for special purposes, design of air compressors, refrigerating machinery, certain forms of electrical machinery, compound engines, and turbines are illustrations of these specialized courses. Such courses as machine design, thermodynamics, or mechanics should cover the required fundamental principles. These are all it is advisable to teach, for the applications involve much study and experience, which can only be acquired after graduation.

Few students come to college with a definite idea of the work before them or of what they want to do. They follow the courses more or less mechanically and at the end select positions largely because of the salary paid, with little reference to the future. In most instances anything beyond the broadest fundamentals will be utterly forgotten by the time there is occasion to use it, if perchance the occasion ever arises. Furthermore practice changes so rapidly that with rare exceptions the student cannot apply his special knowledge without revising it. We must remember that we should look years into the future, for we are preparing the engineers of ten or fifteen years hence, and who will be so bold as to say what engineering practice will be then? We are prone to lose sight of the fact that the four years spent in an engineering school are but the beginning of the student's preparation. We call our graduation commencement, and so it is; that which has preceded is but the clearing of the ground and the laying of the foundation. We speak lightly of foundations and fundamentals, fume over the preparation of the students who come to us, and immediately proceed to rear a topheavy superstructure. Let us, therefore, trim our dead wood and offshoots, eliminate the study of foreign languages, require them for entrance if need be, reduce shopwork and alter it where necessary, eliminate all forms of specialized courses, except for graduate instruction and then only after the student has had several years of practical experience. In the place of these courses put more English, with a greater stress upon the use of English through all the four years, and more work in fundamental sciences, chemistry, physics, geology, biology, mechanics. Such a curriculum may not be ideal, but it is worthy of thought and frank discussion.

THE WISCONSIN COURSE IN THE COMPOSITION OF TECHNICAL PAPERS.

BY HOMER A. WATT,

Department of English, New York University

(Formerly of the English Department at Wisconsin).

Instruction in English composition for engineering students has taken two directions, first, that of a course in general composition similar in most respects to the liberal arts courses in the subject, and, second, a more specific course in the composition of technical papers. The first aims to liberalize the student by giving him a broad intellectual training and by stimulating his intellectual curiosity; its purpose is to make him a better engineer by making him a trained thinker on subjects not immediately connected with his profession.* The second aims more specifically to give the student training in the composition of such technical papers as his profession is likely to demand of him; its purpose is to make him a more articulate *engineer*. The two courses are not antithetical since very much of the value of one course is naturally contained in the other. Moreover, the course in technical writing cannot be called narrow and overspecific inasmuch as the elements composing it remain constant, and the training which it gives the student is of permanent value regardless of any advance in engineering science.

At the University of Wisconsin all engineering students are required to take the course in freshman English; this consists of one semester of drill in whole compositions, paragraphs, and sentences, and one semester of analysis and study of expositions of broad, general interest. Having completed the course in freshman English, the engineering student may elect the course in advanced composition given in the College of Letters and Science or a special course in the composition of technical papers, or both courses if his program permits. Nearly all engineering students who take advanced composition, elect, however, only the technical course especially designed for them. This course has been given for six years to large classes of students from all departments of the College of Engineering. It may justly be said, therefore, to have fairly established itself; and the hope that some of the methods employed may be of interest to other teachers giving similar courses has led me, now severing my connection with the work, to describe briefly the course as it was developed during the six years when it was under my direction.

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* The aims of a course of the first type are outlined in an article by the present writer entitled ''The English Department and the Professional Schools,'' in the BULLETIN of the S. P. E. E. for October, 1916, and are embodied in a collection of essays edited by Professor Frank Aydelotte (''English and Engineering,'' McGraw-Hill Book Company, 1917).

Two general aims which were kept uppermost in the course should be stated before any specific methods are described. The first aim was to preserve the individuality of the student, to keep him from becoming a ''rubber stamp man''; the second was to make him independent of instructor and text-book. ''Every engineering student,'' said one of their instructors the other day, ''is seeking for a universal formula which will solve all his engineering troubles.'' This fact was very neatly illustrated by the experience of another engineering instructor, who recently asked his class of seniors to write letters of application. Almost without exception the letters were of the same cut—formal, frigid, dull, and absolutely conventional. Upon inquiry the instructor discovered that almost all his students had modeled their letters after one printed in a well-known text-book on commercial correspondence, copied them even to the extent of writing in every case, ''I feel fully qualified to fill the position.'' The model was good enough as a model, but it was, of course, absolutely lacking in individuality. In the course in technical writing the students were constantly reminded that every article which they are called upon to write presents to a certain extent a new problem, which has to be studied independently, with full consideration of the reader in the case and of the particular material being dealt with. General principles of clearness and vigor deduced from the analysis of obviously good pieces of exposition were to be used, the students were told, as general guides only. The gain from the course was to come, not from any empty and formal acquaintance with rhetorical principles, but from the power resulting from the actual grappling with and solving of problems in the clear and effective presentation of given sets of concrete or abstract facts or ideas.

The second aim referred to, that of making the student independent, is really a corollary of the first. One of the serious errors in modern university instruction is the tendency to coddle the student, to do too much for him and not to let him do enough for himself. This is the line of least resistance not only for the student but also for the instructor, since it is usually much easier to do a thing for the student than to lead him to do it for himself. And yet our task as teachers is not to make our students, but with all the patience in the world to help them to make themselves. It is always better to insist upon independent work, and not to give the student direct suggestions in connection with his writing where more good will result from his making an independent discovery.

The work done in the Wisconsin course took three directions: class work, themes, and conferences. The students received three credits for the course; for this they spent two hours a week in class, and had one weekly conference, which was substantially a private lesson of from fifteen minutes to half an hour.

The class work consisted in part of informal talks (not *lectures*) on the principles of technical writing. These were liberally illustrated by specimen expositions of the types studied, which were analyzed by the students and discussed freely in class. Expositions were taken from various sources, from books of printed selections, technical magazines, engineering textbooks and pamphlets, and mimeographed material supplied by the instructor. Occasionally students were asked to bring to class copies of the technical journals for which they subscribed and to read from these articles of general interest which they regarded as structurally good or bad. They were then asked to point out the good or bad qualities of the articles read and to make suggestions, in the second instance, for improvement. These talks and discussions formed the core of the class work. Variety was introduced, however, by drill in reconstructing bad sentences from themes and engineering magazines, by a critical examination of government pamphlets on technical subjects, published reports, advertising and publicity pamphlets, contracts, and specifications, of all of which material an abundant supply was kept on file, and by an annual lecture on the use of the engineering library generously given by the librarian. Two weeks in May were devoted to a critical study of student and other reports, and two weeks more to a study of business letters of the types usually written by engineers. All this class work was conducted as informally as possible. Students were expected to join freely in the discussions, and were invited to contribute to the files of specimen expositions printed articles which seemed to them to be worth analyzing.

The themes fell into three divisions: first, a series of five hundred word papers, one each week; following these a long paper of two thousand words or more due near the end of the semester; and finally a series of reports and letters written during the last four weeks of the course. Each short theme was supposed to be an example of the type of exposition then under discussion in class; for example, when descriptive-exposition was being studied, the students would submit technical descriptions of simple machines or of pieces of laboratory apparatus, or would explain the arrangement of a power plant or heating station which they had recently visited. The themes were not highly technical. Most of the students had had previous to their entering the course only the general courses of the first year or two in the engineering college.

Moreover, the theme work was based largely upon the propositions that by no means all writing done by an engineer is addressed to engineers, and that the engineer who can make himself understood by a layman will have no trouble in being sufficiently technical when occasion demands. Students drew their material for the themes, for the most part, from what came to hand in their laboratory and field work; they were encouraged, moreover, to submit accounts, when they had any to submit, and they quite often did, of pieces of apparatus and methods of their own devising. All of these short themes were carefully corrected by the instructor, at least fifteen minutes being spent on each one, and returned to the students. Then, after they had formed the basis of the week's conference, they were corrected or rewritten by the students and returned to the instructor, often so changed that little of the original remained.

The writing of the long theme I believe to have been one of the most valuable parts of the entire course. The work was begun early in the semester, when a class hour was devoted to a talk on the science of constructing papers of considerable length, and a conference held with each student to assist him to select an appropriate subject, and was continued throughout the semester, until, after a preliminary outline and sample introductory section had been written and duly approved, the finished paper was finally submitted. For all but the seniors in the course the long theme amounted substantially to a junior thesis, in so far, at least, as the problem of constructing the composition was concerned. The choice of the subject was one of the most important parts of the work. It was insisted that the student possess a genuine interest in what he was to write about. One of the serious mistakes in composition teaching comes, I believe, from the assumption that a student can produce a really vital or even readable piece of writing on a subject in which he has not the slightest interest. What man in active life would send to any magazine, professional or popular, an exposition which was not the expression of a real interest? And is it not almost insulting to a student to ask him to spend hours of his college life—short and precious as it is—upon a subject which he cares nothing about, even though his efforts may give him a certain amount of expository drill? If he ever had any interest in composition, there is no more certain way of killing it. Excepting, then, in the case of a very few apathetic students, every theme subject represented a real student choice, and some of the papers were even, within narrow limits, just as genuine contributions as many more pretentious ones. Sometimes the long theme was a trip report involving a description of a power plant, fully illustrated with photographs taken by the author; sometimes it was a civil engineering student's plan for municipal improvements in his home town; sometimes it was a chemical engineering student's conception of how some chemical process might be put to a new use. Or, from students interested in the commercial and economic side of engineering would come an account of the workmen's opinion, from first-hand evidence, of an efficiency system, or suggestions for an improvement in the arrangement or management of some shop in which the writer had worked, or the story of the failure of a colonizing scheme in which the author had once participated, or perhaps a sales or publicity pamphlet explaining the construction and insinuating the merits of some machine. The solidity and real worth of a number of these papers is attested by the circumstance that several were published. The honest increase in self-respect and self-confidence which came to the student who saw his composition in print was alone worth to him the time spent upon the course, and the simple exhibit of printed articles "written by members of earlier classes" did much to stimulate younger brothers. In reading the papers I played variously the rôles of gentleman farmer, interested capitalist, prospective buyer, city councilman, and general reader of a popular science magazine. Although the papers were the most difficult to correct of any which fell to my lot during the year, I do not remember that I was bored by very many of them; on the contrary, most of them proved very entertaining.

Next to the long themes, the individual conferences were perhaps the most productive part of the course; this, at least, was the testimony of many students. As has been said, these conferences were essentially private lessons of from fifteen minutes to half an hour in duration. They were an integral part of the work; students were required to attend regularly and were marked absent for non-attendance. The plan of regular, individual conferences added to the instructor's teaching program from five to six hours of intense work each week; but the results amply justified the extra labor. The conference was a business meeting, and not much time was given over to talk about the weather or the latest baseball game. The theme of the preceding week formed the center of the discussion. It had been corrected and returned to the student, and he had examined it before coming to the office. There we went at it hammer and tongs and analyzed it from beginning to end with especial emphasis upon those faults to which the student seemed peculiarly liable. I always took great pains to commend the student for his good work as well as to point out his errors. Perpetual fault-finding even in themes of the poorest student defeats its own end; it discourages the student who is in peculiar need of encouragement and often removes incentive to further effort. It is usually much more productive of good results to say pleasantly, ''Now this is very good at this point; let me see if you can't do it again,'' than to explode in black damnation of a piece of work which may have cost the student hours of labor. Unless there was overwhelming evidence to the contrary, I always assumed that, as a matter of course, the student's work represented on his part a serious effort of considerable duration, and I was always careful to meet him half way by praising wherever I could conscientiously do so. Following the theory, furthermore, that a student's real gain comes from his discovery of his own errors, I never pointed out a defect directly where I could lead the student to discover it for himself. In composition teaching one of the most difficult problems is that of making the student genuinely self-critical. Usually he makes little or no effort to revise his compositions thoroughly until they come back from the instructor splashed with red ink. But in self-criticism alone lies self-confidence in writing, and independence of instructor, and textbook, and course in composition.

A great deal of whatever measure of success the Wisconsin course has enjoyed came, as might have been expected, from the encouragement and active support given the course by members of the engineering college faculty, and especially from the circumstance that the students were for the most part earnest and high-minded. In fact, I do not believe that there is any better type of student in America than the junior and senior engineers. Disciplined by the drill of the early years of their college course and already beginning to have a vision of the responsibilities which lie even at the threshold of the great profession of which they will soon be members, they face present duties with an earnestness and cheerfulness which stimulates any instructor who is not case-hardened. And such students it is a pleasure and not a duty to instruct.

TREASURER'S REPORT.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

June 21, 1917.

Trading Account.

6/16/16 Inventory	$3,203.10	
Cost of Publications*	4,254.80	
Less Inventory of 6/21/17	3,193.55	
Cost of Sales		$4,264.35
		$4,264.35
Sales of Publications to members and non-members.	$534.91	
1/4 of members dues	1,443.50	
3/10 of institutional dues	177.75	$2,156.16
Advertising	$1,047.50	
Less discount	16.40	1,031.10
		$3,187.26
Balance-Profit and Loss account. *Loss*		1,077.09
		$4,264.35

Profit and Loss Account.

Annual Meeting 1916	$193.79	
Balance-Trading Account		$1,077.09
Committee Expenses	133.75	
Treasurer's Honorarium	303.79	
Secretary's Honorarium	1,000.00	
Assistant Secretary's Honorarium	600.00	
Secretary's Clerical Assistant†	795.10	
Postage and Expresses	392.75	
Telephone and Telegraph	24.63	
Office Supplies	133.91	
Annual Meeting 1917	87.69	3,665.41
		$4,742.50
Balance-Profit for year		16.18
		$4,758.68
		$4,758.68
Dues—Individual (3/4)	$4,330.50	
Dues—Institutional (7/10)	414.75	
Exchange	.56	
Interest on deposit	12.87	$4,758.68
		$4,758.68

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* Does not include cost of *Bulletin* for June.

† Does not include June expenses.

TREASURER'S REPORT.

BALANCE SHEET.

ASSETS.

Accounts Receivable:		
Individual		
Current Dues, B.B.	$2,140.00	
Back Dues, A.A.	1,787.22	
Institutional		
Current Dues		
E.E.	200.00	
Back Dues		
Non-members (C.C.)	233.09	
At Dr. Bishop's Office	88.22	$4,448.53
Cash:		
Lincoln Trust Co.	$669.16	
Life Membership Fund	397.20	
Dr. Bishop's Office	150.00	$1,216.36
Inventory		3,193.55
		$8,858

LIABILITIES AND SURPLUS.

Accounts Payable G. G.	$3,279.50
Members paid in advance (D.D.)	58.60
Due Non-members F. F.	3.60
Life membership	397.20
Surplus	5,119.54
	$8,858

COMPARATIVE BALANCE SHEET, S. P. E. E.

1915–16

COMPARATIVE BALANCE SHEET.

	1915–6.	1916–7.	Increase.	Decrease.
Accounts receivable:				
Back Dues	$1,216.26	$1,787.22	$570.96	
Current Dues	1,558.26	2,140.00	581.74	
Other Items (Members)	26.14			$26.14
Institutional Dues	105.00	200.00	95.00	
Non-members	377.73	233.09		144.64
At Pittsburgh	23.68	88.22	64.54	
Cash:				
Life Membership Fund	397.20	397.20		191.51
Lincoln Trust Co.	860.67	669.16		
Secretary's Office	150.00	150.00		
Inventory	3,203.10	3,193.55		9.55
	$7,918.04	$8,858.44	$1,312.24	$371.84
			371.84	
			940.40	

1916–17.

	1915–6.	1916–7.	Increase.	Decrease.
Accounts Payable	$2,159.23	$3,279.50	$1,120.27	$29.50
Due Members	88.10	58.60		1.10
Due New Members	4.70	3.60		149.27
Surplus	5,268.81	5,119.54		
Life Membership	397.20	397.20		
	$7,918.04	$8,858.44	$1,120.27	$179.87
			179.87	
			$940.40	

June, 1916. a/c Payable does not include cost of *Bulletin* for March, April, May and June.

June, 1917. a/c Payable does not include cost of *Bulletin* for June.

EDITORIAL.

Engineering Societies and Education.—Dean Benton calls attention in the September number of ENGINEERING EDUCATION to the almost universal rule of engineering societies which make graduation from an engineering college equivalent to two years of practical work.

This requirement arises from the fact that there are two aspects of the engineering profession, one the art or trade of engineering, and the other, the true profession of engineering. It is much easier to define the first than it is the second. It is the profession of engineering which is, and should be taught in engineering schools. The art or trade of engineering should be learned from practical experience both before and after graduation.

Graduation from a recognized engineering school is now the most distinguishing single and common attribute of all engineers. Why not then go a step further than Dean Benton suggests and *make graduation the fundamental requirement of admission to real professional engineering societies and in lieu of this the candidate should present not less than ten years of practical experience?*

HAVE YOU PAID YOUR DUES? IF NOT DO IT NOW. MAKE OUT YOUR CHECK PAYABLE TO W. O. WILEY, TREASURER, 432 FOURTH AVENUE, NEW YORK CITY, FOR CURRENT AND BACK DUES AND THUS AVOID THE NECESSITY OF SENDING OUT A THIRD BILL.

COLLEGE NOTES.

Iowa State College.—*S. W. Beyer,* Professor of Geology and Mining Engineering and Vice Dean, assumes the duties of Dean of Engineering, left vacant when Dean Marston received a commission as Major in the Iowa National Guard. Major Marston is now located at Camp Cody, near Deming, New Mexico. *C. S. Nichols,* Assistant to the Dean, will carry on the work along sanitary engineering lines formerly assumed by Professor M. I. Evinger, who is at the present time doing commercial work. *T. R. Agg,* Professor of Highway Engineering, assumes the duties of Captain in the Officers' Reserve Engineering Corps. *J. S. Dodds,* formerly with the Iowa Highway Commission, fills Professor Agg's place in the college. *B. F. Hastings,* of Bridgeport, Conn., occupies the place formerly held by B. S. Myers, who is now with the Kansas City Structural Steel Company. *R. A. Pochel,* of Minot, N. Dak., formerly assistant City Engineer of that city, takes the place of B. F. Hopkins. *B. Kamrass* becomes laboratory assistant in the Highway Department of the Engineering Experiment Station. *J. F. H. Douglass,* Assistant Professor of Physics, has accepted a position with the Texas Agricultural College. *Wm. Nyswanger,* of the same department, has been granted a leave of absence on account of his health. *J. C. Pomeroy,* instructor in Physics, has resigned to accept a position in the Physics Department of "The Citadel," Charleston, South Carolina. *Harl Boileau,* instructor in Mechanical Engineering, is now with the Allied Machinery Company, of New York City. *Harry Gruwell,* one of the special men in the Mechanical Department, is now superintendent of the machine shops at Highland Park College, Des Moines. *F. B. Sisler* is instructor in telegraphic code practice, for Signal Service preparation, a new position created on account of the co-operative work the college is undertaking, to aid the United States Signal Corps. *G. H. Montillon,* former graduate student in Chemical Engineering, received the appointment of teaching fellow. *John E. Smith,* formerly of the University of North Carolina, was appointed to the position of Assistant Professor in Geology.

Massachusetts Institute of Technology.—The faculty changes have introduced some new problems since there has been so much demand by the U. S. Government and by industrial corporations related to the war for men of technical skill. On the other hand the demands for instruction have not only not decreased, for the registration is but slightly less than normal with much the same distribution through courses, but are to a considerable extent greater for the Institute is furnishing instruction in academic and engineering lines to the important schools of aeronautics for the army and the navy, and is carrying on no less than three schools for deck officers and the school for marine engineers.

Some of the changes are the retirement of Professor Charles R. Cross, with the title, Professor Emeritus, and the appointment of Professor E. B. Wilson of the department of Mathematics to the chair of Mathematical Physics and head of the department of Physics. Professor C. L. Norton has been appointed professor of Industrial Physics, an option which is assuming more and more importance, and Dr. Charles R. Mann has been appointed professor of Education and Educational Research.

Purdue University.—In the School of Electrical Engineering, the following changes have occurred in the personnel of the department staff:

Professor L. D. Rowell has been commissioned a Captain in the Engineer Officers' Reserve Corps and is now in active duty as the Recorder of the Board of Engineer Troops, Washington, D. C.

Messrs. J. B. Sheadel and H. E. Phelps, Instructors in Electrical Engineering, have resigned, the former entering the Service of the Union Traction Company of Indiana, and the latter that of the American Telephone & Telegraph Company of New York.

Most of the members of the departmental faculty spent the summer vacation in engineering work of some kind or other. Professor C. Francis Harding was with the engineering department of the Commonwealth Edison Company. Professor Alfred Still was engaged with a revision of his text book on "Overhead Electrical Transmission Lines." Professor D. D. Ewing, as a special representative of the editorial staff of the Electric Railway Journal, visited a number of electric railway properties. Professor R. V. Achatz was engaged in a study of telephone transmission conditions on the lines of the Michigan Telephone Company.

The effect of the war upon the enrollment in the Schools of Engineering is indicated by the following statistics:

School.	Year.	Number of Students.			
		Freshmen.	Sophomore.	Junior.	Senior.
Electrical	1916	117	87	64	49
	1917	99	57	40	37
Mechanical	1916	121	92	74	59
	1917	81	67	54	37
Civil	1916	77	44	44	45
	1917	66	46	20	22
Chemical	1916	84	51	38	25
	1917	91	44	30	21

Stevens Institute of Technology.—Prof. Albert F. Ganz, head of the department of electrical engineering, passed away on July 27. L. A. Hazeltine, formerly assistant professor, has been appointed acting head of the department. The following instructors have been promoted assistant professors: F. C. Stockwell, electrical engineering; G. G. Freygang, mechanics; L. A. Belding, mechanical engineering; L. H. Backer, chemistry. The following instructors have been newly appointed: H. Fezandié, mechanical engineering; G. M. Weimar, English and logic; C. H. Bertolf, descriptive geometry and mechanical drawing. Instructor E. Byron has been transferred from descriptive geometry and mechanical drawing to physics. C. E. Hedden, formerly instructor in mechanism and machine design, has accepted an assistant professorship in vocational education at the Carnegie Institute of Technology.

BOOK REVIEWS.

The Design of Railway Location. By CLEMENT C. WILLIAMS, Professor of Railway Engineering, University of Kansas. First edition. New York, John Wiley & Sons, Inc. Cloth 6 × 9. 517 pages. $3.50.

The purpose of the author clearly sets forth the fundamental principles underlying railway location for the assistance of teachers and students of technical schools rather than providing a reference book on the subject. It is intended primarily as a text but there is much material contained in the work which will be of value to those engineers engaged in practical railroad work.

The volume considers location chiefly from the standpoint of regrouping and relocation now becoming necessary on account of the difference in traffic and operating conditions from those obtaining when the roads were built. Beginning with a brief historical review of railway development in America, railway organization, Government control of railways, valuation, effect of volume of traffic, operating expenses, and rate making are taken up. Steam and electric locomotives are classified and compared and the results of tests shown. The practical engineer will find useful the chapter on momentum grades and the effect of rise and fall upon operating costs. He will consider the volume rather elementary in parts but from the standpoint of the student this is desirable. The work gathers together in one volume of convenient size practically all the fundamentals concerning the important branches of railroading.

L. W. McI.

Principles of Electrical Design.—Direct and Alternating Current Generators. By ALFRED STILL, Professor of Electrical Design, Purdue University. Author of Overhead Electric Power Transmission, and Polyphase Motors. McGraw-Hill Book Co. 1917. 6 × 9. 365 pages, 146 illustrations. Cloth. $3.00 net.

A text book on design written primarily for the electrical engineering student, and not intended as a reference book for the finished designer. Exceptional stress is laid on visualizing the work in hand. While fundamental principles and theories are definitely adhered to, they are presented in such a manner as keep the physical " action " ever before the student. Illustrative design sheets are worked out for specific designs.

H. E. D.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

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Milo S. Ketchum, G. R. Chatburn, F. L. Bishop, *Editor*.

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THE ENGINEERING SCHOOL AND THE WAR.*

BY A. F. BARNES,

Dean, Engineering School, New Mexico A. & M. College.

In bringing this subject before you as the first presidential address of this Society, I want to say that I have had but little time to work on it, for not until the directors' meeting of October 6 was it decided to have this address. I believe it is an excellent plan, and I am anticipating with considerable pleasure the opportunity to listen to a much better paper next year from the new President soon to be elected.

As to the subject, "The Engineering School and the War," it is a vital one, and, as you will note, the title does not restrict my endeavors to a particular effect of the conflict on our schools. I purposely selected a general title, for so many questions are arising, and will continue to arise, relative to this matter that it seemed best to attempt to cover in a general manner the more important phases of the question than to treat a single aspect in an exhaustive way. As the war continues, both the engineer and the engineering school will face new problems, and no doubt many of my present impressions will be entirely changed a year from now. It will be necessary in treating this subject to touch upon industrial conditions and the standing of the engineer in America today and after the war. For only in this way may technical courses be kept abreast of the new conditions of industry.

Manufacturing and industry in America developed in the form of small shops and plants, and in our early history the demand for trained engineers did not warrant educational direction along this line. In spite of many difficulties, manufacturing increased and the natural resources of this country were gradually developed until in the early years of the nineteenth century it became more and more difficult to secure skilled labor. This brought about, in the year 1823, an agitation for the founding of so-called ''industrial schools.'' The result of this was the birth of the Rensselaer Polytechnic Institute and the Franklin Institute. From 1825 to 1860 our natural resources and industries developed very fast, and engineering was greatly stimulated by the building of canals and railroads and the invention of such important things as the McCormick reaper, the telegraph, and the sewing machine. Every new invention seemed to intensify the demand for greater knowledge of science and its application. This demand became so great that in 1857 it could be denied no longer, and the Morrill Bill was introduced into Congress, and passed in 1862. This was the foundation and is still the backbone of engineering education today. I should mention that about this time there were established, notably in the larger centers of population, privately endowed schools specializing on what was then called ''practical education.'' It is worthy of note that the engineering schools were founded by college professors who saw the need of such training and in the face of bitter opposition on the part of their more conservative colleagues, who even went so far as to encourage students preparing for the learned professions to look on their more practical classmates as beneath them. The achievements of engineering have, however, brought about the recognition of the fact that knowledge of practical arts is essential to the education of every American.

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* The Editor is desirous of securing, for publication in ENGINEERING EDUCATION, articles on the effect of the war upon the engineering schools. In publishing in this number the presidential address of Dean A. F. Barnes before the Southwestern Society of Engineers, we are presenting one phase of this subject.

During the past fifty years, engineering and industry have gone forward by leaps and bounds, the small shops have become the great factories of our Eastern cities, the demand for men has increased so fast that the engineering schools have had unusual growth, and today the engineering college of 700 to 800 students is not unusual. With this rapid growth of industry came the requirement of specialists in the several branches, and to meet this, highly specialized courses have been developed. The kind of man to meet this industrial need has been largely what I choose to call a producing type—a man who can do things and bring about immediate results, but, I fear, in many cases, not thoroughly grounded in the fundamental sciences. Further, until recent years there has been no general recognition of the necessity for training in the problems of organization and management. It should be noted here that the larger organizations have developed industrial research laboratories, conducted in the most cases by experts of long service with the company, and but few young men have taken up this work. The smaller companies have had to be content with what research assistance they were able to engage in a consulting capacity, in order to overcome difficulties beyond them.

What has happened to American industries since the outbreak of the European War, as affects engineering education?

1. Many industries, both large and small, have been nearly paralyzed by the lack of certain raw materials previously imported from Europe, together with increased requirements of greater quantities of others, to meet the unprecedented needs of manufacturing war implements for the belligerents.

2. This country has felt the shortage of certain finished products which were formerly imported. This has brought about attempts at manufacture of new products, by many concerns.

3. The great demand for munitions has developed a mammoth new industry. This unusual activity has created a need for a large number of engineers of two classes: (1) a research type, and (2) an executive type.

I would mention here that in only a small percentage of engineering schools has research been systematically conducted, and that the introducing of courses looking toward the training of men to enter organization work has only been carried out in the last few years. Further examination will show that the faculties of these schools are not generally familiar with the requirements of research and organization.

During all this time the engineer has been content to take a back seat in civic life and has been too well satisfied with the praise of his immediate superior, leaving the occupancy of state and municipal offices to the politician and the lawyer. With the declaration of war by this country has come the intensifying of the demand for large numbers of men qualified to fill executive and research positions. But with this unfortunate condition that our country is facing, has come the complete recognition that the engineer is the man of the hour, if not, in fact, the savior of our country. This is very evident by the formation of many special boards and commissions, the personnel of which is composed largely of engineers, and further, it is apparent by even a casual investigation of the problems of this war that the engineer must make good if we are to win.

In addition to this need of more and better engineers, patriotism and duty have caused many technical men to enter the army and navy, which has greatly increased the shortage in the industries. To offset this, the national engineering societies have taken upon themselves the gathering of complete data and the classification for service of not only their membership, but have extended it to include any engineers that may be brought to their attention. Moreover, there has been formed an engineering council, consisting of representatives of all the larger societies, which contemplates the interlocking and the interweaving of all engineering organizations in America. It meets a real need, and should do much to bring about proper consideration of the many vital questions which the engineer is preeminently fitted to solve, and will bring united action upon questions of common interest. You may be interested to know that our distinguished and honored guest, Dr. Hollis, was very active in its organization, and is now its permanent chairman.

At the outbreak of the war, federal officials quickly realized that as a supply depot of defense and to meet the need of engineers for the reconstruction period after the war, the engineering, as well as other professional schools, must be kept going and enrollment even increased, if possible. To bring this about, early in May, college presidents from all over the United States were hurriedly summoned to Washington, upon request of the Committee on Science, Engineering and Education, of the Advisory Commission of the Council of National Defense. At this conference a statement of principles was adopted, the substance of which was:

1. That all young men below the draft age should be urged to continue their education, in order to render the most effective service during the period of the war and at the trying time which will follow the war.

2. That all colleges should modify their calendar and curricula to speed up production of trained men, recommending specifically that the college carry on work continuously, dividing the year into approximately four quarters of twelve weeks each.

3. That technical students, in view of the supreme importance of applied science in the present war, would render, through the continuation of their training, more valuable and efficient service than if they enrolled in military or naval organizations.

4. That military training should be given in all schools, as provided for in the National Defense Act of June, 1916.

5. That the Bureau of Education of the Department of the Interior, and the States Relations Service of the Department of Agriculture, with the coöperation of the Committee on Science, Engineering and Education of the Advisory Commission of the Council of National Defense, should be the medium of communication between the federal government and the higher educational institutions.

This Advisory Commission has pursued vigorously the focusing of public attention upon the desirability of keeping the higher institutions in full operation during the war, in order that the supply of trained men might not be cut off. In order to bring greater weight to bear on this fundamental question, the Committee held a three-day conference with a commission representing the Canadian universities. At this conference the depleted condition of our allies' universities and the shortage of trained men were brought out, and recommendations were formulated to prevent our country from suffering in a like manner.

The effect of this was a letter from Commissioner of Education Claxton, suggesting that college presidents should apply for exemption from military service for their promising technical students, and do all in their power to expedite the early finishing of their courses. However, this was soon followed by a second communication revoking these instructions, as it was found that there was nothing in our draft law to warrant such exemption.

The result of all of this is that the enrollment in the engineering colleges of this country is less than normal, by from 10 per cent. to 50 per cent. In a few instances normal attendance and even an increase is reported.

The larger part of this falling off is, naturally, in the senior and junior classes, statistics reported showing a loss in these classes of from 25 per cent. to 90 per cent. In some instances the entire senior class has gone. The two lower classes are more nearly normal, and an increased enrollment in the freshman class has materially offset the losses of the upper years.

That this condition is not worse is due in part to publicity efforts of the national agencies that have been mentioned, and to local forces, such as direct publicity from the engineering colleges, and the realization by parents that this is a scientific war and that their sons must be trained to meet its problems.

The result of this falling off in enrollment, together with the cry for trained men in the industrial and military world, has left only 15 out of 64 institutions from which statistics were gathered reporting full faculties, with a total of 206 vacancies.

It is still too early yet to know definitely all changes that have come to the engineering schools, although some of the principal consequences may be outlined. For direct service, there has been established in Washington a central Intelligence Bureau, which is undertaking to put Washington officials in touch with trained men through the medium of representatives at each institution. This has brought about a complete canvass of faculty, students, and alumni, which, though in part a duplication of the work of the Engineering Council, is reaching many good men otherwise unknown.

A second service to the government is the establishing in many of the larger institutions, under government supervision, of special training schools in aëronautics, signaling, naval engineering, patrol boat-operation, automobile practice, etc.

A third service undertaken by several institutions is the attack of special research problems by members of the faculty, while in still other instances members of the faculty are acting as advisors on special questions confronting the army and navy engineers at this time.

Up to the present time, no general change has come in the curriculum of the engineering school, except as follows:

1. Many schools opened later than usual this year, in order to allow students to assist in the harvesting of crops and other food conservation work.

2. The four-quarter plan of twelve weeks each, as recommended by the Conference of College Presidents, has been adopted by several colleges, thus reducing the length of the regular four-year course to three years.

3. Military drill and military subjects have been introduced in some institutions not giving such courses heretofore, and in a number of schools already giving such work, the time devoted to it has been materially increased.

4. In other colleges, courses of a vocational nature have been established, to turn out trained workers and vocational

teachers. This is in part the outcome of the provision of the Smith-Hughes Act recently passed by Congress.

The question is, what may take place in the engineering schools if the war continues long? There is little likelihood that students will be exempted from military service, and further, there is a probability that the age of liability for draft will be lowered. It would seem, therefore, that upper classes will continue reduced in numbers, for the average age of students at graduation is well above twenty-one years. However, the necessity of keeping up the supply of trained men is so vital that, no doubt, public sentiment approving sending young men to technical schools until they reach the age of liability will help greatly to maintain normal enrollment. To what extent, it is hard to predict.

There is every indication that as the many national boards and commissions become more completely organized, they will make use of the engineering schools' facilities and laboratories to a greater extent, the two most probable ways being: (1) For special training of officers and enlisted men in the technical branches of the army, (2) the assigning of special research problems to those institutions best fitted to handle them.

Another possibility is the further introduction of vocational courses to meet the call for skilled men needed in both the industrial and military service, with the possibility of furnishing special courses for trained workers to educate them for foremen and superintendents.

As to the place of the engineer in the world at the close of hostilities, there is, I believe, but one answer, and that is, he will stand in the public eye as *the man* of the country.

Further, he must bear the burdens of the upbuilding of a broken Europe and play the principal rôle in transferring the industries of this country from a war to a peace footing. His worth will be well understood and will result in his more and more being called upon to occupy executive positions both in industrial and in public life.

The extension of foreign trade to Mexico and Latin American countries now just begun will offer further opportunities for him.

If not established before the end of the war, research laboratories will be started under federal aid and control. It is probable that they will be carried out in the Land Grant Colleges or other state institutions, as has already been advocated in our last Congress. These laboratories will do much not only in the solving of problems coming up in connection with national defense and welfare but will be of great assistance to the small manufacturer and will stimulate new industries. As to the large corporation, from lessons learned in this emergency, they will expand their research activities.

All of these factors will tend to modify the engineering college and broaden its field of activity.

In the curriculum itself, courses teaching duty and loyalty to government, together with military training, will hold an important place. It is also probable that the more efficient plan of conducting schools during the entire year will become permanent in many institutions.

The need of men to fill the gap between the skilled worker and the general manager will possibly bring about a new type of course in which the Cincinnati system, or plan, requiring the student to work alternate weeks, or months, in a commercial establishment will find a prominent place.

The need of greater breadth and organizing ability for executive positions both in industrial and public life will tend to increase the length of the regular four-year course. This may bring about the more general requirement of a regular college course as a prerequisite to professional engineering study, as is so commonly practised in medicine and law. Moreover, the curriculum will surely have to give more attention to the problems of management and organization.

To meet the needs of the expansion of research and from the stimulus of government support, new courses especially designed to develop the research type of mind will be introduced.

All of these things will require careful experimentation and study of the schools, but with advice, and the coöperation of the practising engineer, satisfactory solution will come, and we will turn out a better and more efficient man to practise the greatest of all professions, namely the art and science by which the natural forces and materials are utilized for the benefit of mankind.

SYMBOLS FOR MECHANICS AND HYDRAULICS.

BY JOHN T. FAIG,

Professor of Mechanical Engineering, University of Cincinnati, Chairman, Committee on the Standardization of Technical Nomenclature, Society for the Promotion of Engineering Education.

For about a year a committee of the Society for the Promotion of Engineering Education has been working upon symbols for mechanics and hydraulics in the hope of standardizing practice. Perhaps the following statement of the methods followed, and the results obtained so far, may be of interest.

Letters were sent to professors of mechanics and hydraulics who are members of the society, and to some other persons. Each letter requested the recipient to suggest the symbols that he thought should be standards in mechanics and hydraulics.

Eighteen replies were received.

13 replies were accompanied by lists of symbols;

4 replies favored a standard list, but submitted no specific suggestions;

1 reply opposed standardization of symbols by the committee.

The following submitted lists:

O. H. Basquin,	Northwestern University;
J. E. Boyd,	Ohio State University;
G. R. Chatburn,	University of Nebraska;
I. P. Church,	Cornell University;
R. L. Daugherty,	Rensselaer Polytechnic Institute;
Wm. Kent,	Montclair, N. J.;
A. L. Jenkins,	University of Cincinnati;

E. R. Maurer,	University of Wisconsin;
John McGowan,	University of Toronto;
E. K. Ruth,	University of Cincinnati;
S. E. Slocum,	University of Cincinnati;
G. S. Thompson,	Rensselaer Polytechnic Institute;
E. H. Wood,	Cornell University.

The suggestions made in an article in the *Engineering News-Record* of April 12, 1917, by R. Fleming, of the American Bridge Company, were also tabulated.

The symbols suggested were charted on a large sheet and tabulated, with the result given in the following list.

SUMMARY OF THE SUGGESTIONS RECEIVED, OMITTING THOSE CONCEPTS OR SYMBOLS THAT WERE SUGGESTED IN ONE LIST ONLY.

Concept.	Symbol.	Number of Lists Suggesting It.
Acceleration, angular	α	6
Acceleration due to gravity	g	11
Acceleration, linear	a	6
Area	A	8
Breadth	b	7
Center of rotation	O	3
Coefficient of friction	μ	4
	f	2
Coefficient of roughness, Kutter	n	2
Coefficients	C, c	2
Compressive stress	C	2
Constant	K	3
	c	2
Deflection of beam	y	3
	D, Δ	2
Deformation or elongation, unit	ϵ	3
	δ	2
Depth	d	9
Diameter	d	9
Diameter of shaft	D	4
Distance	s	3
	d	2
Distance of extreme fiber from neutral axis	c	5
Eccentricity of application of load	e	3

Concept.	Symbol.	Number of Lists Suggesting It.
Efficiency (hydrau., mech., vol.)	e_h, e_m, e_v	2
Energy	E	2
Energy, kinetic	$K.E.$	2
Elongation, unit deformation or	ϵ	3
	δ	2
Force	F	8
	P	3
Force, moment of	M	4
Forces, or stresses, tensile	T	2
Force or load, total	W	5
Force or load, unit	w	7
	p	5
Friction, coef. of	μ	4
	f	2
Friction factor, hydraulic	f	5
Head	H, h	9
Height	H, h	9
Horsepower	$H.P.$	4
	$h.p.$	3
Hydraulic coefficient	c	5
Hydraulic friction factor	f	5
Hydraulic radius	r	4
	R	2
Hydraulic slope	s	6
Inertia, polar moment of	J	6
Inertia, rectangular moment of	I	13
Length	L, l	11
Load, eccentricity of application of	e	3
Load, total concentrated	P	6
Load, total force or	W	5
Load, unit force or	w	7
	p	5
Mass	M, m	6
Modulus of section	S	5
	Z	3
Modulus of elasticity, Young's	E	12
Moment, bending	M	8
Moment of force	M	4
Moment of inertia, polar	J	6
Moment of inertia, rectangular	I	13
Pressure, total	P	3

Concept.	Symbol.	Number of Lists Suggesting It.
Quantity of liquid flowing	Q, q	7
	W	2
Radius	r	9
	R	4
Radius, hydraulic	r	4
	R	2
Radius of gyration	r	7
	k	5
Radius of shaft	R	4
Reactions	R	6
Resultant	R	5
Shear	S	3
	V	2
Span of beams	l	2
Stress, compressive	C	2
Stress in member, total	$S_{t, c, s}$	2
Stress, shearing	q	3
Stresses, tensile forces or	T	2
Stress, unit	$S_{t, c, s}$	3
	f	3
	p	2
Tensile forces or stresses	T	2
Thickness of any plate	t	4
Time	t	6
Torque	T	9
Velocity, angular (rad./unit of time)	ω	7
Velocity, angular (rev./unit of time)	$r.p.m.$	3
	n	3
	N	2
Velocity, linear	v	9
Volume	V	4
Weight	W	7
	G	2
Young's modulus of elasticity	E	12

The foregoing list was mimeographed and sent to about 50 professors, editors and engineers. Accompanying each mimeographed copy was a letter which stated the method followed in making the list and which requested criticisms.

Following are the names of nineteen persons who sent replies that contained criticisms and suggestions. .

L. P. Alford	Editor (New York)
F. E. Ayer	Professor (Akron)
O. H. Basquin	Professor (Northwestern)
I. P. Church	Professor (Cornell)
R. L. Daugherty	Professor (Rensselaer)
A. L. Jenkins	Professor (Cincinnati)
Wm. Kent	Engineer (Montclair, N. J.)
A. B. McDaniel	Professor (Union College)
W. T. Magruder	Professor (Ohio State)
R. C. Matthews	Professor (Tennessee)
H. F. Moore	Professor (Illinois)
R. E. Plimpton	Editor (New York)
I. D. Potter	Professor (Kansas State)
A. L. Rice	Editor (Chicago)
N. C. Ross	Engineer (Cincinnati)
E. K. Ruth	Professor (Cincinnati)
R. F. Schuchardt	Engineer (Chicago)
S. M. Woodward	Engineer (Dayton)
R. B. Woodworth	Engineer (Pittsburgh, Pa.)

The committee also received suggestions from representatives of some of the national engineering societies and from a number of prominent publishers of engineering books.

While the number of names is not large, the list is fairly representative. The editors approved heartily of the idea of a standard list and objected to all Greek letters except π; otherwise they did not care particularly what symbols were selected. This attitude was also that of most of the practising engineers. Professors went into considerable detail and had strong preferences, but differed widely in their views. Those professors who had had the largest experience in writing and whose works are best known were favorable to the list. This was exactly contrary to the expectations of the committee.

A majority of the replies approved of a standard list based on the one submitted. In the light of the suggestions received the following list was made.

SYMBOLS SUGGESTED BY THE COMMITTEE.

Concept.	Symbol.
Acceleration, angular	
Acceleration due to gravity	g
Acceleration, linear	a
Area	A
Breadth	b
Center of rotation	O
Coefficient of friction	f
Coefficients and constants	C, K
Deflection of beam	Y
Depth	d
Diameter	D
Distance passed over	s
Distance of extreme fiber from neutral axis	c
Eccentricity of application of load	e
Efficiency (hydrau., mech., vol.)	e_h, e_m, e_v
Force	F
Force, moment of	M
Friction, coefficient of	f
Head	H
Height	h
Horsepower	H_p
Hydraulic radius	R_h
Inertia, polar moment of	J
Inertia, rectangular moment of	I
Length	L
Load, eccentricity of application of	e
Mass	m
Modulus of section	Z
Modulus of elasticity, Young's	E
Moment of force	M
Moment of inertia, polar	J
Moment of inertia, rectangular	I
Quantity of liquid flowing	Q
Radius	r
Radius of gyration	k
Reactions	R

Concept.	Symbol.
Revolutions per unit of time	N
Stress, unit	S
Time	t
Torque	T
Velocity, angular	w
Velocity, linear	v
Volume	V
Weight	W
Young's modulus of elasticity	E

Previous lists of symbols have not secured wide acceptance in this country. Some lists that have been proposed by prominent writers are familiar to very few engineers. It was apparent that the chief difficulty to be overcome was not in the formation of a list of symbols, but in securing the acceptance of the list. The method followed by the committee has been to collect evidence regarding present practice and to present it. The list obtained by this method has disadvantages. The symbols composing it are not of the same order of importance. Many omissions, some of importance, occur. But it is believed to hold the nucleus of a standard list of symbols for this country, because it is composed of symbols that are in general use. Objection has been raised on the point that professors and writers, rather than engineers, have been consulted in its making. But it is the professors and writers who are largely responsible for the present chaotic situation with regard to symbols and it is only by concerted action of these that some order may be brought out of chaos. Engineers and editors appear willing to accept any list *that will be accepted generally.* The list is presented in the hope that it will assist in the evolution of a standard list. It is short. It contains no Greek letters. It is mnemonic to a considerable degree, though not by intention. It deals largely with mechanics because that branch is common to all the divisions of engineering. For those who are interested, the list is shown in slightly altered form on the following pages. Some letters, it will be observed, are unassigned.

SYMBOLS FOR MECHANICS AND HYDRAULICS.

List of Symbols Suggested by Committee.

A	Area.
a	Linear acceleration.
B	
b	Breadth.
C	Constant.
c	Distance of extreme fiber from neutral axis.
D	Diameter.
d	Depth.
E	Young's modulus of elasticity.
e	Eccentricity of application of load.
e_h, e_m, e_v	Efficiency (hydraulic, mechanical, volumetric).
F	Force.
f	Coefficient of friction.
G	
g	Acceleration due to gravity.
H	Head.
H_p	Horsepower.
h	Height.
I	Rectangular moment of inertia.
J	Polar moment of inertia.
K	Coefficient, constant.
k	Radius of gyration.
L	Length.
M	Moment of force or sum of moments of forces.
m	Mass.
N	Revolutions per unit of time.
n	
O	Center of rotation.
P	Concentrated load.
p	
Q	Quantity of liquid flowing in pounds.
q	
R	Reaction.
R_h	Hydraulic radius.
r	Radius.
S_t, S_c, S_s	Unit stress in tension, compression, shear.
s	Distance passed over.
T	Torque.
t	Time.
U	
u	
V	Volume.

v	Linear velocity.
W	Weight of a body or total weight.
w	Angular velocity.
X	
x	
Y	
y	Deflection of beam.
Z	Modulus of section.
z	

The members of the Committee on Technical Nomenclature, S. P. E. E., are John T. Faig, Chas. Warren Hunt, E. N. Raymond and W. D. Ennis.

SOME OBSERVATIONS REGARDING THE METHODS OF TEACHING THE THEORY OF REINFORCED CONCRETE DESIGN.

BY ALLEN B. McDANIEL,

Professor of Civil Engineering, Union College, Schenectady, N. Y.

"Rule of thumb" methods are unfortunately still prevalent in the technical world. The uneducated man uses them because he does not know better while the trained man often reverts to them for ease, speed, or simplicity. It is a simple process to solve a problem in a routine, empirical manner without any mental exertion. So many engineers regard a formula as a machine into which they may insert certain data, turn the crank and secure the desired results. The results of these mechanical, slip-shod methods are irrational and inaccurate work and low professional standards.

Mental initiative, resourcefulness, and self-reliance are the qualities which distinguish the professional engineer from the technician or mechanic. At the 24th Annual Meeting of the Society for the Promotion of Engineering Education, Professor C. R. Mann, of the Carnegie Foundation and of the Joint Committee of Engineering Societies, gave a report of his investigation for the improvement of American engineering education. One of the most significant parts of this report was the statement of the result of the questionnaire as to the relative importance of the various characteristics which the engineer should possess. The replies from over six thousand engineers, teachers, executives and others gave the qualities of character, judgment, efficiency and understanding of men a rating of 75 per cent. while knowledge of fundamentals and technique were rated at 25 per cent. Professor Mann contended that the proper teaching of the subjects rated at

25 per cent. would give the desired improvement in the qualities rated at 75 per cent. The writer heartily agrees with Professor Mann in his contention and believes that the use of proper methods of instruction in the presentation of all scientific and technical subjects will develop in the student those characteristics which have been so universally agreed upon as essential to success.

The writer has previously stated before this Society his belief that all subjects should be so taught that the knowledge gained may be intelligently applied in practice. This is necessary in order that the student may thoroughly understand the fundamental principles and their application and may acquire the true professional spirit.

Throughout his technical course, especially in the subjects of mathematics, mechanics and the subsequent advanced subjects, the student has to deal with equations and formulas. He should learn that these are mathematical expressions for definite scientific relations. He should be taught to regard these expressions as tools, as a means to an end and not an end in themselves. The student is inclined to use equations as mere abstract expressions and with no understanding of their significance or limitations. Especially is this true in the derivation and use of equations in subjects of an advanced technical nature and which apply the principles of the fundamental courses in mathematics and mechanics. An advanced subject of this nature is the theory of reinforced concrete design.

Let us consider the method of presentation of the theory of the simple rectangular beam in reinforced concrete construction. In a well-known text-book on reinforced concrete construction, the author works out eight formulas which give the relations between the percentage of reinforcement and the area of the steel and the area of the cross-section of the beam, the percentage of reinforcement and the unit safe working-fiber stresses of the steel and the concrete, the proportionate distances from the compression surface to the neutral axis and the percentage of steel and the ratio between the moduli of elasticity of the steel and the concrete, etc.

These formulas are followed by a series of illustrative problems.

The formulas which are collected and presented for use are as follows:

$$p = \frac{a_s}{bd},$$

$$p = \frac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}, \tag{4}$$

$$k = \sqrt{2pn + (pn)^2} - pn, \tag{5}$$

$$M_c = \tfrac{1}{2} f_c kj(bd^2) \quad or \quad bd^2 = \frac{M}{\frac{1}{2} f_c kj}, \tag{6}$$

$$M_s = pf_s j(bd^2) \quad or \quad bd^2 = \frac{M}{pf_s j}, \tag{7}$$

$$f_c = \frac{2f_s p}{k}, \tag{8}$$

What will be the resisting moment (M), for a beam whose breadth (b) is 8 in. with a distance from the center of the reinforcement to the compression surface (d) of 12 in., the area of steel section being 0.96 sq. in.? $E_s = 30,000,000$. $E_c = 2,500,000$. $f_c = 500$ lb. per square inch. $f_s = 16,000$ lb. per sq. inch.

$$n = \frac{E_s}{E_c} = \frac{30,000,000}{2,500,000} = 12.$$

$$p = \frac{a_s}{bd} = \frac{0.96}{(8)(12)} = 0.01.$$

From equation (5)

$$\begin{aligned} k &= \sqrt{(2)(0.01)(12) + (0.01)^2(12)^2} - (0.01)(12). \\ &= .384. \end{aligned}$$

From equation (6)

$$M_c = \tfrac{1}{2}(500)(0.384)(0.872)(8)(12)^2$$
$$= 96{,}500 \text{ in.-lb.}$$

From equation (7)

$$M_s = (0.01)(16{,}000)(0.872)(8)(12)^2$$
$$= 160{,}700 \text{ in.-lb.}$$

M_c is the lesser of the two resisting moments and hence, controls in the design = 96,500 in.-lb.

Suppose that the beam of the preceding problem is 14 in. deep and is subjected to a bending moment of 130,000 in.-lb. Compute the greatest unit stresses in the steel and concrete.

$$p = \frac{a_s}{bd} = \frac{0.96}{(8)(14)} = 0.0086.$$

From equation (5)

$$k = \sqrt{(2)(0.0086)(12) + (0.0086)^2(12)^2} - (0.0086)(12).$$
$$= 0.363$$

From equation (6)

$$130{,}000 = (f_c/2)(0.363)(0.879)(8)(14)^2,$$
$$f_c = 520 \text{ lb. per square inch.}$$

From equation (7)

$$130{,}000 = (0.0086)(f_s)(0.879)(8)(14)^2,$$
$$f_s = 11{,}000 \text{ lb. per square inch.}$$

The writer would suggest the following method of presenting this subject before a class.

As it is assumed in this discussion that the concrete is subjected to working loads and the unit stress in the steel is within the elastic limit and the variation of stress in the concrete is rectilinear, the following fundamental propositions of mechanics may be stated:

(*a*) Any cross-section of the beam which is a plane surface before bending will remain a plane surface after bending.

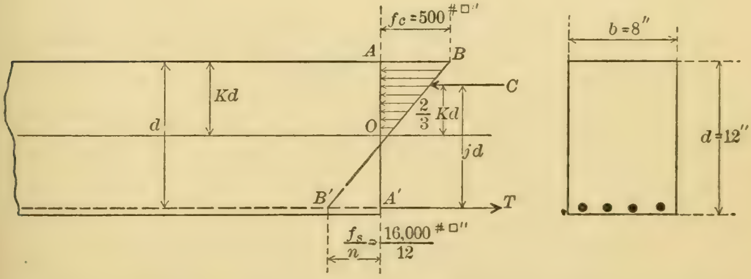
(*b*) The total internal resisting moment on any cross-section of the beam must be equal to the external bending moment at the section for equilibrium.

(*c*) On any cross-section of the beam, the total compressive resistance above the neutral axis must be equal to the total tensile resistance below the same axis.

With these fundamental principles in mind we will proceed with the solution of the above problems as follows:

What will be the resisting moment (M) for a beam whose breadth (b) is 8 in. with a distance from the center of the reinforcement to the compression surface (d) of 12 in., the area of steel section being 0.96 sq. in.?

$$E_s = 30,000,000,\ E_c = 2,500,000,\ f_c = 500 \text{ lb. per square inch},$$
$$f_s = 16,000 \text{ lb. per square inch.}$$



As shown in the above drawing, let the distance from the neutral axis to the compression surface be Kd and the distance between the center of gravity of the steel and the line of action of the resultant compression be jd. The line of action of the resultant compression will be $2/3Kd$ above the neutral axis.

The total compression will be

$$\tfrac{500}{2} \times 8 \times 12K = 24,000K = C.$$

$$M_c = C \times jd,$$

$$M_c = 24{,}000K \times 12(1-1/3K) = 288{,}000K - 96{,}000K^2. \quad (1)$$

The total tension will be

$$16{,}000 \times 0.96 = 15{,}360 \text{ lb.} = T.$$

The moment of the tensile force will be

$$M_t = T \times jd,$$

$$M_t = 15{,}360 \times 12(1-1/3K) \quad (2)$$

$$= 184{,}320 - 61{,}440K.$$

From the figure, we can determine the value of K as follows: In the similar triangles, ABO and $A'B'O$, we have

$$\frac{AB}{A'B'} = \frac{AO}{A'O} \quad or \quad \frac{f_c}{\frac{f_s}{n}} = \frac{12K}{12(1-K)}$$

and

$$n = \frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}500{,}000} = 12.$$

Then

$$f_s = \frac{f_c(1-K)12}{K}.$$

Total compression

$$(C) = 1/2 f_c \times 12K \times 8 = 48 f_c K.$$

Total tension

$$(T) = a_s f_s = 0.96 f_s.$$

Since C must equal T,

$$48 f_c K = 0.96 f_c \frac{(1-K)12}{K}, \quad (3)$$

$$4K^2 + 0.96K - 0.96 = 0,$$

$$K = .384.$$

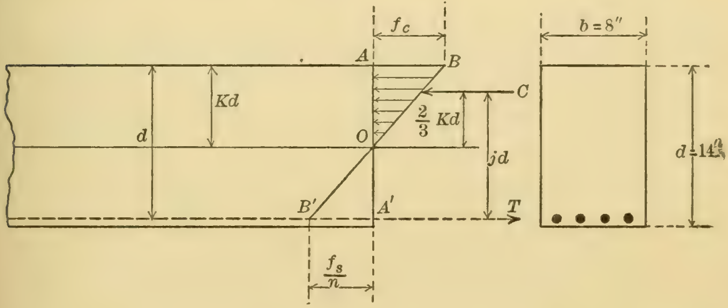
Substituting the value of K given in equation (3) in equations (1) and (2) we have:

$$M_c = 288{,}000(0.384) - 96{,}000(0.384)^2 = 96{,}440 \text{ in.-lb.}$$

$$M_t = 184{,}320 - 61{,}400(0.384) = 160{,}730 \text{ in.-lb.}$$

$M_c = 96{,}440$ in.-lb. is the lesser of the two values and hence, the resisting moment for the concrete governs the design of the beam.

Suppose that the beam of the preceding problem is 14 in. deep and is subjected to a bending moment of 130,000 in.-lb. Compute the greatest unit stresses in the steel and concrete.



Referring to the figure, we can determine the value of K as follows:

In similar triangles, ABO and $A'B'O$, we have:

$$\frac{AB}{A'B'} = \frac{AO}{A'O} \quad or \quad \frac{f_c}{\frac{f_s}{n}} = \frac{14K}{14(1-K)}$$

and

$$n = \frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}500{,}000} = 12.$$

Then

$$f_s = \frac{f_c(1-K)12}{K}.$$

The total compression

$$(C) = 1/2f_c \times 14K \times 8 = 56f_cK.$$

The total tension

$$(T) = a_sf_s = 0.96f_s.$$

Since (C) must equal (T),

$$56f_cK = \frac{0.96f_c(1 - K)12}{K},$$

$$7K^2 + 1.44K - 1.44 = 0,$$

$$K = 0.363.$$

The external bending moment of 130,000 in.-lb. must be resisted by this internal moment of the concrete and of the steel.

The internal resisting moment of the concrete will be equal to the total compression (C) multiplied by its lever arm, *jd*.

$$M_c = C \times jd = C \times d(1\text{–}1/3K).$$

But

$$C = 1/2f_c \times 14K \times 8 = 56f_cK.$$

Hence

$$M_c = 56f_cK \times d(1\text{–}1/3K).$$

$$130{,}000 = 56f_c \times 0.363 \times 14(1 - 0.121),$$

$$250.16f_c = 130{,}000,$$

$$f_c = 520 \text{ lb. square inch.}$$

The internal resisting moment of the steel will be equal to the total tension (T) multiplied by its lever arm, *jd*.

$$M_t = T \times jd = T \times d(1\text{–}1/3K).$$

But

$$T = a_sf_s = 0.96f_s.$$

Hence

$$M_t = 0.96 f_s \times d(1\text{–}1/3K).$$

$$130{,}000 = 0.96 f_s \times 14(1 - 0.121).$$

$$11.81 f_s = 130{,}000,$$

$$f_s = 11{,}000 \text{ lb. per square inch.}$$

Although the second method of solving these two simple problems is a little longer than the first method, it is the rational, commonsense way; the mind of the student perceiving and understanding each step. It is thus entirely unnecessary for the student to remember formulas, all that is necessary is an understanding of a few of the simple fundamental principles of mechanics.

In the presentation of this subject, as is true of any other subject, the well-known pedagogical principles should apply. The so-called Socratic or ‘‘question and answer’’ method of instruction should, whenever possible, supplant the lecture system and the teacher utilize every possible device to require the student to exercise his mental processes and shun all rule-of-thumb methods.

HOW TO AWAKEN FRESHMAN INTEREST IN GOOD SPELLING.

BY A. C. F. BAEBENROTH,

Professor of English, Syracuse University.

Faulty spelling is inexcusable in an age of universal education. Yet the fact remains that most American universities feel under obligation to teach a short course in spelling for all entering students—and what is more humiliating, a long course for many of the entering class. Professor Clark, of the English department of Northwestern University, has reported that as many as sixty per cent. of a class have had to enter what is known as the ''Pity-Sakes'' section for deficient spellers. Employers of college graduates, with monotonous regularity report a chronic weakness in the spelling of the college men in their employ.

It is only common honesty to say at the outset that the university is not in a position to do the student real service in spelling. The nature of the regular work of the course in composition will not allow the intrusion of secondary, and certainly not of primary school work. When the writer of this article was particularly irritated a few years ago by the miserable showing of his freshmen, he compiled his spelling data and sent them to the State Education Department at Albany, N. Y. He received an answer to the effect that the department was giving increasing attention to the matter of spelling, that conditions would continue to improve, and that the college was not in a position to assume the burden which properly belonged on the shoulders of the schools below college rank.

At Syracuse University, however, the college of applied science has for many years held up a percentage of the entering class, in spite of the increasingly good results and heightened interest revealed in the county and state spelling contests. As a result the writer has had to give a certain restricted attention to the subject of spelling, some of the results of which may be of interest to instructors who are discouraged by seeming lack of spelling progress among their technical students.

It is well first of all to impress the student with the importance of the subject. This can be done most effectively by bringing forward the question of conformity to custom, for which there is abundant illustration in everyday life. The student should come to a vivid realization of the fact that in spelling as in other matters of convention, the easiest and least troublesome road is that of conformity. Conformity eliminates friction. The way in spelling is abundantly marked, and what is more important for our present problem, easily followed by an intelligent American youth. But the proper point of view can not be aroused in the student except as the result of personal conviction.

The false notion that good spellers are born and not made should be vigorously attacked. The experience of a thoughtful teacher will provide a fund of instances where an apparently hopeless speller has been turned into a "spelling success." The writer is acquainted with a man who when a freshman absolutely refused to show interest in the subject because he had been obliged to try an examination in the secondary school twenty-three times before he succeeded in "passing." He was convinced that he was not cut out by nature to be a speller of English words. Yet the same man by the end of his college course voluntarily came into the office to confess the error of his initial contention. He was willing to agree with his instructor that many good spellers seem to be born, but that many more are made.

The personal humiliation involved in a misspelling is a potent corrective influence. No young American relishes the thought of humiliation in the eyes of one for whom he entertains respect. The good-natured laugh of his fellows does not take the smart from the sting of having been caught writing such a ludicrous sentence as "This word is hack-kneed"; or "A crick runs through my father's farm"; or "The burgular alarm is not always effishent." Marshall Field, of Chicago, surely a competent authority on business, has put himself on record as saying that misspellings in a business letter are not merely irritating, but what is more, tend to shake confidence.

To the ready plea of the student that faulty spelling is due to carelessness, one can only answer that such carelessness might be forgiven were it not for the deeper implication involved, reflecting as it does on the character of the student. The underlying reason of the carelessness must be made clear to him. If his observation is careless in one direction, the inference in the mind of the majority of practical men of the world is that it will also be in others. Many a man has by poor spelling started his superiors on the road to doubt of his ability.

The philosophical basis of poor spelling, once it is recognized, will reveal the difficulty in a much more serious aspect. Far from being a matter of temperament or inheritance or both, or even of superficial carelessness, faulty spelling may be said to be the result of a fundamental lack in matters of psychology and physiology. It is a matter, the deeper implications of which involve the nervous system.

When a young man of at least average ability insists on writing "burgular," "coive," "sight" (cite), "atheletics," "Wenesday," "hack-kneed" (hackneyed), he is suffering less from poor spelling than from poor hearing and seeing and pronunciation. His optic and auricular nerves probably need the attention of a specialist. His spelling is merely an external sign of what is faulty in all the functionings of his eyes and ears.

The habit of concentration and undivided attention will produce clear-cut sense impressions. As first impressions count for so much, it is essential that the optic nerve report the word so sharply that there need be no doubt in the future about the accuracy of the original impression. The ear must hear so keenly that there is no garbling of sounds. An ear accustomed to ''cemetry'' will inevitably lead the brain to signal that wrong form whenever *cemetery* is wanted. If the ''g'' in *recognize* is habitually elided in speech, it will as a matter of course not appear in the written form.

The young man who wishes to be enrolled in the ranks of educated persons must learn to cultivate himself if nature or his experience of life has left him with senses that do not function efficiently. Spelling appears in a more serious aspect when it is realized that for most men poor spelling is the result of senses working muddily. Infinitely more than spelling is taught when the matter is explained in this way. If a young man can be made to respect his body, the first step in the progress toward accuracy of perception has been taken. As a rule, and this applies in the vast majority of cases, bad spelling is merely an indication of a general lack in a student's nervous make-up. The alert and at the same time really efficient students are not troubled by spelling. What is meant to be conveyed is general efficiency in all branches, and activities. The point is that the senses must be kept pure. And spelling is fundamentally a matter of their proper functioning.

It is not the object of this paper to convey the impression that these suggestions will carry student and teacher all the way through the pitifully long list of words misspelled by freshmen in technical schools. Such words as *accommodation, embarrass, supersede, benefited, indispensable,* and others of a different type, depend on mnemonics of one sort or another. Etymology when sensibly used and focused on the needs of the technical student, can be made to appeal to that higher form of perception, the functioning of the imaginative faculty. The etymologies of *embarrass* and *supersede* in our list are sufficiently vivid and concrete, if only a teacher can muster imagination enough to present them in a lively way. Furthermore, special rules for digraphs, for word accents, for prefixes, and for suffixes, will help the student to fix a difficult word in his memory. The teacher probably has a magazine of helpful suggestions for this large class of difficult spellings. But the point to be emphasized here is that for certain types of faulty spelling no suggestion will be vitally awakening and stimulating to the technical student if the underlying philosophical reason for his weakness is not brought home to him.

The good students will naturally be interested in the philosophical aspects of the explanation; whereas the bad spellers, who as a rule are skeptical about all phases of English, will wake up to the new point of view. They will be attentive because the matter of the five senses is just real and practical enough to them to bring the matter of spelling into a new focus. Practically every student I know anything about can be appealed to on the score of the purity of the senses. He will see the point at once if he is a technical student, say in forestry or engineering. My foresters especially seem to be alive to the out-of-door illustrations I use at this point to bring out the need of that keenness in touch and sight so necessary to successful woods life. It is not difficult to appeal to the engineer on somewhat similar ground, though the illustrations had better be drawn from the life of a marine engineer or from the field of civil engineering. At any rate my experience would seem to indicate that they can be most readily drawn from those sources because of the problem of adaptation necessary with freshmen.

The instructor who has never tried this method of leavening the dull mass of uninterested youth (that is, not interested in English) will be astonished at the vitalizing power of the methods suggested above. If the teacher is sure of himself, he may go on to such matters as the discrimination of *sensual* and *sensuous,* driving home the main point not to the heart of the sermon element in the distinction, but to the core of the spelling problem which the analogy is to illuminate.

The writer has got a response where a response in the real live sense was difficult or even impossible to get by any other method. Once the student realizes the deeper implications of a weakness he has come to tolerate with a careless ease, he will be fired by a new enthusiasm for correct spelling.

REPORT OF AUDITING COMMITTEE.

New York City, November 5, 1917.

Executive Committee,
Society for the Promotion of Engineering Education,
University of Pittsburgh, Pittsburgh, Pa.

Gentlemen: Acting under authorization from your Committee, we have examined the books and accounts of the Treasurer of the Society for the Promotion of Engineering Education for the fiscal year ending June 21, 1917, and certify that in our opinion the funds of the Society have been fully and faithfully accounted for and are pleased to report that we found the books to be correct and in good order.

The following accounts payable at the end of the fiscal year, June 21, 1917, we herewith approve:

Dean F. L. Bishop, Secretary	$575.00
Prof. L. H. Harris, Assistant Secretary	350.00
New Era Printing Company	2,354.50
Total, Accounts Payable	$3,279.50

Respectfully submitted,
Auditing Committee,
A. H. Blanchard, Chairman,
C. R. Mann, per A. H. B.,
Henry H. Norris.

Dues Payable June 21, 1917.

535 members owed current dues of	$2,140.00
254 members owed back dues of	1,787.22
20 Institutions owed current dues of	200.00
Total	$4,127.22

EDITORIAL.

What changes will the war make in the curricula of engineering schools? This is without doubt a question of primary importance today. It is proposed to publish in ENGINEERING EDUCATION a number of papers on this subject. The papers should develop discussion and thus tend to crystallize the subject which is now so very indefinite. Are these changes the same as those which would have developed in times of peace, and simply accelerated by the war?

The Editor believes that among others the following changes will probably develop:

(*a*) Much greater attention to the relation of the individual and his profession to the government;

(*b*) A smaller number of subjects in the curriculum;

(*c*) A greater coördination between the concrete experience of the student and the presentation of the subject;

(*d*) Placing some of the junior and senior laboratory subjects, after modification, in the earlier years and some of the mathematics and science of the first years later;

(*e*) Greater attention to the economic aspects of engineering.

Members are urged to take part in the discussion of this subject.

COLLEGE NOTES.

College of the City of New York.—To take the place of the late Professor C. H. Parmly in conducting the courses in engineering, D. B. Steinman, C.E., Ph.D. (Columbia), has been appointed professor in charge of civil and mechanical engineering. Dr. Steinman was formerly professor of civil engineering at the University of Idaho, and subsequently was assistant to the chief engineer in the design and erection of the Hell Gate arch bridge at New York City and other notable bridges. He retains his connection as a member of the firm of

Waddell & Son, consulting engineers, of Kansas City and New York.

OTHER SOCIETIES.

The Southwestern Society of Engineers held its annual meeting in El Paso, Texas, October 18 to 20 inclusive. The sessions were given over almost exclusively to army engineering; one morning session being devoted to pontoon bridge building, field surveying, fortification work and trench building at the Eighth Engineers' Camp and Ninth Engineers' Camp. The papers presented were of a military nature, the principal ones being the presidential address by Dean A. F. Barnes on "The Engineering School and the War," "The Engineer in the Present War," by Dr. Ira N. Hollis, "Some Effects of the Draft Law on the Arizona Mining Industry," by Dean G. M. Butler, and "Problems in Army Cantonment Construction," by C. A. Tilton, of Camp Cody.

BOOK REVIEWS.

Strength of Materials. By JAMES E. BOYD, M.S., Professor of Mechanics, The Ohio State University. McGraw-Hill Book Co. 1917. 6 × 8¼, 375 pages.

The new edition of this work is much improved over the old one. It has been re-arranged to develop the subject more logically. The addition of new methods for deriving the equation of the elastic line of beams and the inclusion of a chapter on "Curved Beams" and "Hooks" make the book complete. The book covers the subject of strength of materials in an interesting and practical manner which will appeal both to instructors and students.

W. R. W.

Lubricating Engineer's Handbook. By JOHN ROME BATTLE (B.S. in M.E.). J. B. Lippincott Company. 1916 (second printing). 6½ × 9¼ cloth. 333 pages. $4 net.

This book is intended for oil salesman, purchasing agent, manager, designer, operating engineer and mechanician and it is ideal for that purpose. It is divided into five parts: Part One, Friction, Lubricants and Tests; Part Two, Miscellaneous Notes; Part Three, Bearing Lubrication; Part Four, Lubrication of Various Machines, and Part Five, Costs and Specifications. The illustrations are well chosen and the descriptions of the different problems are excellent. The work covers the field in a far greater degree than perhaps any other published work and should adequately fill the need for which it is intended.

D. D.

BULLETIN

OF THE

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A GENERAL METHOD FOR PERIODIC CURRENTS.

BY JOHN MILLS,

Western Electric Co., New York City.

The study of alternating-current phenomena in the curriculum of the technical school is usually postponed until the student has acquired some dexterity with the analytical tools furnished by trigonometry and calculus. The graduate of the high school has received no training in these subjects, which are the bases of our present-day electrical light and power industries, and of our present electrical methods of communication, whether wire or wireless, telephonic or telegraphic. The purpose of this paper is not to advocate an extension of the subject matter of the high-school course in physics. The writer wishes rather to show that the physics and algebra of the high-school course furnish a sufficient basis, without further formal training in mathematics, for the solution of what are usually considered difficult problems of alternating currents.

By the phrase "further formal training" he means calculus and trigonometry as presented in the current mathematical text-books. In one sense the method which will be described involves both trigonometry and calculus; in fact, it also involves some differential equations. But let us forget the formal classification and consider the method. The method, as the reader will quickly recognize, is not original with the writer, although the consistent presentation of the essential portions of the method in an elementary form is probably original pedagogy.*

Assume a soldier facing in any direction and let him be operated upon by the command "About Face." He turns 180°

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* A complete presentation of this method as made to a class is given in the writer's recent book "Radio-Communication."

to the left. To an aviator above him the operation appears as a rotation of the line of direction of the soldier through 180° counterclockwise. The command "About Face" is then an operator reversing the direction in which the soldier is facing. A reversal in mathematics is indicated by a negative sign. If, then, our soldier has rotated on his left heel, the position of his left toe* instead of being "1 foot," as originally, is — ("1 foot"), that is $-1(1 \text{ foot})$. In other words, we indicate the result of the operation of rotating a unit length of line through 180° counterclockwise by the symbol (-1). If we operate again by (-1), that is by "About Face," we obtain the original foot direction. We indicate this operation by $-1(-1)$, which is of course 1. We may say that this checks or we might define the operator by saying that it is of such a character that when applied twice in succession it restores the original state of affairs.

Now, in military terminology we have another operator, namely "Left Face," which is defined by the fact that when applied twice in succession it is equivalent to the operator "About Face." Let us therefore adopt a similar operator, and since the one we already have is used as a prefix or coefficient, we shall use a coefficient in this second case. Thus "i," meaning "Left Face" is an operator rotating the direction foot through 90° counterclockwise. Thus $i1$ is 90° counterclockwise from 1. If we operate upon $i1$ by i, that is if we write $i(i1)$ or, for convenience, $i^2 1$, where the superior 2 indicates the number of successive times the operator is applied, we have $i^2 1 = -1(1)$. It is absolutely beside the point to say that the laws of exponents lead us to $i = \sqrt{-1}$, if we assume them to apply. This process does not constitute a definition of i, as the student is led to suppose, but a definition of $\sqrt{-1}$; a pure abstraction, for which we have no use in this paper.

If our soldier's direction foot was originally east, we may

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[*] Our hypothetical soldier may be assumed to have a F.P.S. system foot.

symbolize east as $1 \cdot E$, north as iE, west as $iiE = i^2E = -E$ and south as $iiiE = i^3E = -iE$. Now, as any boy of high-school age may recognize, you can express any direction by telling how far one must go to the east (or west) and how far north (or south), in order to arrive at a point on the desired line of direction. In other words, any direction can be expressed by telling two distances at right angles to each other. Thus a general expression for a direction to a point and also of the line to it from the origin (from the location of the soldier, if you prefer) is $\pm M \pm iN$ where M and N are distances. For example a distance of X, east, is found by putting $M = X$, and $N = 0$.

Hence in Fig. 1 if OC is the reference direction, any other direction, as OC', is $a + ib$. We may, of course, think of this line OC', as expressed above, that is, in terms of a distance a along the reference axis and a distance b, laid out along this direction and then rotated by the operator "i" as indicated in Fig. 2. On the other hand, as we remember our soldier, we may think of the line OC' as being the result of operating upon OC of Fig. 1, to rotate it through the angle COC', which we shall call θ. We wish, then, to prefix to OC some symbol representing an operator (that is the operation and its result) which will turn OC' through θ counterclockwise. Let us use $\epsilon^{i\theta}$ and write $\epsilon^{i\theta}(OC) = OC'$. Or if OC is of length c then $OC' = \epsilon^{i\theta} c$.

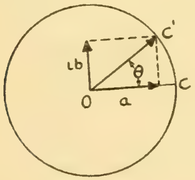

FIG. 1.

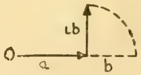

FIG. 2.

But we have just seen that OC' is $a + ib$. This newly chosen operator must be consistent with this previous result. Hence

$$\epsilon^{i\theta} c = a + ib. \tag{1}$$

If the line OC is made $1/c$ times as long then the lengths a and b must also be $1/c$ times as large. Or in symbols

$$\epsilon^{i\theta}\left(\frac{1}{c}\cdot c\right)=\frac{1}{c}\cdot a+\frac{1}{c}ib$$

or

$$\epsilon^{i\theta}=\frac{a}{c}+i\frac{b}{c}, \tag{2}$$

Of this relation we shall make use in a moment.

Returning to Fig. 1 let us consider the line OC to be a particular spoke in a wheel which revolves about an axis through O. Assume the wheel to revolve uniformly making f revolutions per second and thus having an angular velocity of $2\pi f$ radians per second. For convenience write $\omega=2\pi f$. If, then, we start the second hand of our watch when the selected spoke passes the position OC, its later position will be given by the angle θ where $\theta=\omega t$ and t is given by the watch.

The continuous rotation of the spoke is then expressed by substituting ωt for θ in ϵ^{i} and remembering that t, the time, increases steadily. What shall we now substitute on the right-hand side of the equation? It is evident that a and b of Fig. 1 vary as ωt increases. Let us first get a picture of the variations in b by attaching a light to the rim end of our spoke and allowing this light to illuminate a horizontally moving photographic film placed behind the vertical slit S of Fig. 3. [Of course we may obtain a picture of the same result by projecting OC' vertically after the manner of the mechanical draftsman.] The trace which we obtain is a wavy or sinuous line. We call this trace sinusoidal. Physically and pedagogically there seems to be much justification for approaching trigonometry in this way. It is further to be noted that in this way the student is introduced at once to the general idea of the sine of any angle.

Starting our consideration of the trace when our watch starts it appears that the spot of light moves up to a peak, back to its mid-position, that is, zero position, down to a trough or minimum and back to zero, during one complete revolution of the spoke. The displacement of the spot of light on the photographic record from its zero position is a sinusoidal displacement and depends upon the angular position of the spoke. [If the radius of the spoke is increased the successive displacements are proportionally increased. If we know the displacements for a circle of unit radius we may find them for any other size of circle by simple proportion. Now in equation (1), b represents the displacement of the spot of light corresponding to the angular position, θ, for a circle of radius c. But in equation (2) we have b/c representing the displacement for a unit circle.] Let us call the sinusoidal displacement for a unit circle the sine of the angle ωt and abbreviate it to sin ωt. Hence we may now write for b/c the expression sin ωt.

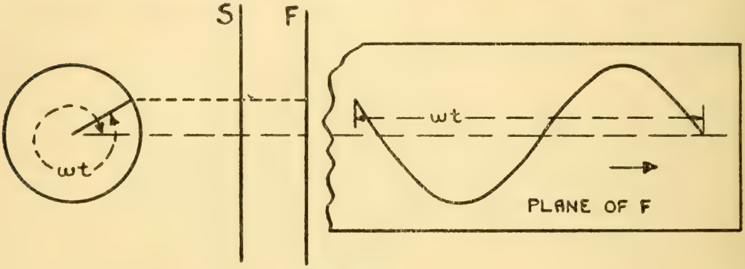

FIG. 3.

How about a/c? If our vertical slit S of Fig. 3 is moved around O as an axis for 1/4 turn it is in a position to record the variations in a/c. These displacements will also be sinusoidal but evidently will not start at zero time from zero, but from unity. Let us give a distinctive name to this new sinusoidal motion of the spot of light and call the displacement the cosine of the angle or cos ωt. Then we write

$$\epsilon^{i\omega t} = \cos \omega t + i \sin \omega t. \qquad (3)$$

[To define the cosine more accurately note that cos ωt is the same sinusoidal curve as we obtain if we start our watch one quarter of a period later than we did in obtaining the sine curve; or in other words, cos ωt is the sine curve which would be obtained if the spoke was allowed to rotate a quarter revolution, that is $\pi/2$ radians before we started the watch. Hence

$$\cos \omega t = \sin \omega(t + T/4) \quad \text{where } T = 1/f$$

and

$$\cos \omega t = \sin(\omega t + \pi/2)$$

are definitions for the cosine of an angle.]

In equation (3) we have the expression for a rotating vector in terms of two sinusoidal components which are at right angles to each other. Suppose that the vector is to be rotated clockwise; how shall we represent it? Obviously, if the direction of rotation is reversed we must reverse the sign of "i" giving

$$\epsilon^{-i\omega t} = \cos \omega t - i \sin \omega t. \tag{4}$$

This vector with the reversed direction of rotation we shall call the conjugate of the original vector.

Now note that the sum of two conjugate vectors (as obtained by adding equations (3) and (4) is a sinusoidal function of the time since rotation started. Thus

$$\epsilon^{i\omega t} + \epsilon^{-i\omega t} = 2 \cos \omega t. \tag{5}$$

Remembering that a cosine function represents a sinusoid we see that equation (5) permits us to represent any sinusoidal wave motion, e. g., an electrical oscillation, in terms of a rotating vector and its conjugate. The convenience of this representation will appear shortly. [Note that it is not rigorous to use equation (4) or equation (3) to represent a sinusoid for these equations each represent two different sinusoids, one of which is commonly spoken of as imaginary. Now the simple harmonic motion of an electron in a wire carrying an alternating current is in no sense imaginary, and on this basis alone should not be represented by an expression involving a so-called imaginary.]

Returning to Fig. 1 let us see how to represent a vector which starts at $t = 0$ not from the position OC but from some position θ radians in advance, as OC'. The vector OC' is $\epsilon^{i\theta}\, OC$. If this vector, OC', is to be rotated with the velocity ω we merely operate upon it by $\epsilon^{i\omega t}$ giving the desired vector as $\epsilon^{i\omega t}\epsilon^{i\theta}(OC) = \epsilon^{i(\omega t+\theta))}(OC)$. This vector is always θ radians ahead of $\epsilon^{i\omega t}(OC)$ and is therefore said to lead it in phase by θ. Its conjugate is of course $\epsilon^{-i(\omega t+\theta)}(OC)$.

Now let us consider the electrical problem of finding the effective value of a sinusoidal alternating current of frequency f and maximum value I_m. Let the current be

$$I = \frac{I_m}{2}(\epsilon^{i\omega t} + \epsilon^{-i\omega t}). \tag{6}$$

The effective value is the square root of the average value of the square. [The occasion of this definition in the phenomenon of the heating effect is not considered here for the sake of brevity.] Then the square is

$$I^2 = \frac{I_m^{\ 2}}{4}(\epsilon^{2i\omega t} + \epsilon^{-2i\omega t} + 2\epsilon^0)$$

or

$$I^2 = \frac{I_m^{\ 2}}{4}(\epsilon^{i2\omega t} + \epsilon^{-i2\omega t}) + \frac{I_m^{\ 2}}{2}. \tag{7}$$

What is the square? Obviously, it is a sinusoidal effect of double frequency and an effect of zero frequency. The average of the double frequency sinusoid is zero. The average of the zero frequency effect is of course its steady value, $I_m^{\ 2}/2$. Hence

$$I(\text{eff.}) = \frac{I_m}{\sqrt{2}}. \tag{8}$$

[The reader may be interested in the simplicity of the proof that the average power is E(eff.)I(eff.) cos θ. To show this* write both E and I in the general form shown in equation (6), but give to them a phase difference of θ, multiply, neglect the double frequency sinusoid and remember that $2 \cos \theta = \epsilon^{i\theta} + \epsilon^{-i\theta}$ as follows from equation (5).]

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* This theorem is thus developed in "Radio-Communication."

A further convenience of the form of expression given in equation (5) appears in the case of alternating current circuits involving inductance and capacity. The self-inductance, L, of a circuit is defined as the ratio of the E.M.F. across its terminals to the "rate of change" of current in it. Thus $E/pI = L$ where the prefix "p" is an operator representing the result of obtaining the rate of change of the quantity to which it is prefixed. [The term "operator" and this entire concept should not be difficult. What is the speedometer of an automobile? It is an operator which we prefix to a car to obtain at any point in the machine's travel (that is for any value of S, the total distance the car has gone) the rate of change of space (that is pS).] The capacity of a circuit may also be expressed in terms of a current, and a rate of change of voltage, but it is sufficient to illustrate the method by using inductance only.

It is then evident if an alternating current of I, where $I = (I_m/2)(\epsilon^{i\omega t} + \epsilon^{-i\omega t})$, flows in an inductance L that the E.M.F. required is LpI. To find pI note that $I_m/2$ does not change and that what we really wish to know is $p(\epsilon^{i\omega t} + \epsilon^{-i\omega t})$, that is, $p\epsilon^{i\omega t}$ and its conjugate. [Simple reasoning will convince one that the operator p is associative. Thus symbolize interest rates on money in terms of p.]

Consider Fig. 4 where are shown $\epsilon^{i\omega t_1}$, and $\epsilon^{i\omega t_2}$. If ωt_2 is

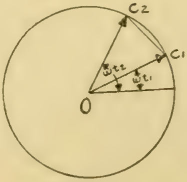

FIG. 4.

not much larger than ωt_1, it appears that the quantity C_1C_2 which must be added to OC_1 (*i. e.*, $\epsilon^{i\omega t_1}$) in order to obtain

OC_2 (*i. e.*, $\epsilon^{i\omega t_2}$) differs but imperceptibly from the arc of the circle. Now the angle $\omega t_2 - \omega t_1$ is measured by this arc, thus

$$\omega t_2 - \omega t_1 = \frac{\text{arc } C_1C_2}{OC_1} = \frac{C_1C_2}{OC_1}.$$

Hence C_1C_2, which is the change in the rotating vector, is $C_1C_2 = OC_1(\omega t_2 - \omega t_1) = \omega(OC_1)(t_2 - t_1)$. The change per second is then

$$\frac{C_1C_2}{t_2 - t_1} = \omega(OC_1)$$

and is of direction C_1C_2, that is perpendicular to the radius OC_1. This perpendicularity is of course to be indicated by prefixing the operator "i" thus $i\omega(OC_1)$. That is

$$p\epsilon^{i\omega t_1} = i\omega(OC_1) = i\omega\epsilon^{i\omega t_1},$$

or in general

$$p\epsilon^{i\omega t} = i\omega\epsilon^{i\omega t},$$

and if

$$I = \frac{I_m}{2}\epsilon^{i\omega t} + \frac{I_m}{2}\epsilon^{-i\omega t}$$

then

$$pI = \frac{i\omega I_m\epsilon^{i\omega t}}{2} + \frac{-i\omega I_m\epsilon^{-i\omega t}}{2}.$$

The E.M.F. E is then $L\omega(I_m/2)(i\epsilon^{i\omega t} - i\epsilon^{-i\omega t})$. This may be put in the more usual form by noting that in equation (3) if $\omega t = \pi/2$ then $\epsilon^{i\pi/2} = i$ since the cosine for a quarter revolution is zero and the sine unity. Similarly from equation (4) $\epsilon^{-i\pi/2} = -i$.

Hence

$$E = \frac{L\omega I_m}{2}(\epsilon^{i(\omega t + \pi/2)} + \epsilon^{-i(\omega t + \pi/2)}).$$

In other words, the E.M.F. required to overcome the self-induction is also a sinusoid but is $L\omega$ (or $2\pi fL$ times as large) and leads the alternating current by 90°. To the reader who has studied alternating currents this result is of course familiar.

If the currents with which we deal are not sustained but are decaying they may be represented by vectors which, in rotating, trace spirals instead of circles and for which the sinusoids are damped. Such vectors are of the form $\epsilon^{-at}\epsilon^{i\omega t}$. Hence the general expression for an alternating current may be written

$$I = \frac{I_m}{2}(\epsilon^{-at+i\omega t} + \epsilon^{-at-i\omega t}). \qquad (10)$$

Now for illustration consider a circuit containing a resistance of R ohms and an inductance of L henries. What is the current in the circuit due to a steady E.M.F. of E volts from a battery? Start our watch at the moment the battery is connected. (At this instant the current is of course zero.) At any instant after starting the E.M.F., E, impressed on the circuit must equal that required to force the current through the resistance plus that required to force it through the inductance. If I represents any instantaneous value of the current then

$$E = RI + LpI. \qquad (11)$$

Since the battery will ultimately force a steady direct current through the circuit let us represent I by the sum of two component currents, one the forced current which will ultimately flow, say I_0, and the other a transient current which we will write in general form as $(I_m/2)(\epsilon^{(a+i\omega)t} + \epsilon^{(a-i\omega)t})$. Then

$$I = I_0 + \frac{I_m}{2}(\epsilon^{(a+i\omega)t} + \epsilon^{(a-i\omega)t}) \qquad (12)$$

and

$$pI = \frac{I_m}{2}[(a + i\omega)\epsilon^{(a+i\omega)t} + (a - i\omega)\epsilon^{(a-i\omega)t}]. \qquad (13)$$

Now when $t = 0$, we have $I = 0$, hence putting $t = 0$ in equation (12) gives

$$O = I_0 + \frac{I_m}{2}[2] \quad \text{or} \quad I_m = -I_0.$$

But by Ohm's law the ultimate steady forced current will be

$$I_0 = \frac{E}{R}. \tag{14}$$

Hence

$$I_m = -\frac{E}{R}. \tag{15}$$

Also when $t=0$ we have from equation (13)

$$pI = \frac{I_m}{2}[2a]. \tag{16}$$

Now equation (11) holds for every instant and therefore for the instant when t is zero. At this instant $I=0$, and

$$LpI = LaI_m = -\frac{ELa}{R}$$

by equations (15) and (16). Hence substituting these values in equation (11) we have

$$E = R\cdot 0 - \frac{ELa}{R} \quad or \quad a = -\frac{R}{L}. \tag{17}$$

Substituting from (17) and (14) in equations (12) and (13) and then in equation (11) gives

$$E = E + \frac{E}{2R}[iL\omega\epsilon^{(a+i\omega)t} - iL\omega\epsilon^{(a-i\omega)t}]. \tag{18}$$

But equation (18) can only hold if ω is zero; that is from this equation we obtain $\omega=0$. Hence substituting $\omega=0$ and $a=-R/L$ in equation (12) gives

$$I = \frac{E}{R}(1 - \epsilon^{-Rt/L}). \tag{19}$$

[It is not necessary to solve for ω if it is recognized that of the two types of storage reservoirs for energy, namely, inductance and capacity, only one is present in this circuit and hence energy transfers from one type to the other type cannot occur. That is, there can be no alternations in the direction of the current and hence the only current possible is one of zero frequency, that is of zero angular velocity.]

Summary.—The method which has been presented and illustrated by three examples may be summarized as follows: (1) The concept of the vector operator "i"; (2) the concept of a rotating vector and its expression as in equation (3); (3) the rate of change of a rotating vector; (4) the concept of a conjugate vector; (5) the representation of a simple harmonic motion, e. g., an alternating current, by the sum of two conjugate vectors; (6) the representation of a damped alternating current by the sum of two conjugate vectors which are similarly reduced exponentially. With the tools thus obtained, the transients of spark set wireless transmitters, the oscillations of tuned and coupled circuits, the currents in unbalanced three phase circuits, the impedances of transmission lines and other similar magnitudes may be dealt with quantitatively by purely algebraic methods. As a by-product of this method we have a suggestion for a method of approaching trigonometry which might be used with some types of students to shorten the time now required for its study.

A NEW POINT OF VIEW IN LABORATORY WORK.

BY WALTER LYMAN UPSON,

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It is not my wish to press too hard the claim of novelty. There are many laboratories with which I am naturally quite unfamiliar. So far as I know, however, the general method, or system, advocated is not at present in force anywhere except partially in the Union College electrical laboratory. I must also acknowledge that my experience is somewhat limited to engineering, and more particularly to electrical engineering laboratories. There need be, however, no such limitation on the application of the system, for it is based on principles applicable to all subjects taught, even to those which do not at present ever make use of the laboratory or of laboratory methods.

The first element in my ''point of view'' is the laying of emphasis upon *individual creative work.* In this connection I wish to express my satisfaction at finding recently most convincing support of the general idea on which I am working in Professor Henry Fairfield Osborn's little book entitled ''Huxley and Education.'' The idea which he develops is summed up in a word, which I quote, from page 9, namely ''. . . the lesson of Huxley's life and the result of my own experience is that *productive thinking* is the chief *means* as well as the chief *end* of education, and that the natural evolution of education will be to develop this kind of thinking earlier and earlier in the life of the student.''

The second element is the laying of emphasis on the laboratory as against the class room. I think that generally the laboratory follows, and is in a sense subordinate to the class room. I would emphasize the laboratory at the expense of the class room, even to the point of making it paramount.

The object of this is to secure free play to the laboratory for the theoretical investigation and pursuit of problems developing therein.

As I have been working over the above principles and their application, the whole system of college, and even of secondary, education has become involved in a most fascinating and far-reaching way. When it comes to putting them into practice, however, it is only practicable for me now to do so in a very limited way, beginning with small things, so to speak, in the hope of finding therein justification for their further extension to the larger sphere. Bearing these two principles in mind, then, and especially the first regarding individual creative work, I propose to relate something of what is going on in my laboratory courses at the present time, hoping thereby to give concrete expression to the real meaning of the incorporation of these ideas into the educational process.

A short time ago, a junior came into my office in the laboratory to say that he had obtained very peculiar results in his experimenting of the previous day. We discussed the work for about five minutes, and he went out to make further investigation. His problem related to the change in resistivity of an electrical conductor under variation of tension. Having previously made a few determinations of resistivity, he undertook to build apparatus by which a piece of wire could be gradually stretched while current was passing through it. The apparatus was completed a few days ago, and yesterday, his regular laboratory day, he made his first series of tests. At the present time I have reason to believe that he is really interested in the fundamental law of resistivity and in the electrical properties of conducting materials. He has created something himself, namely the apparatus which he designed and built after suggestions from me. There is still before him the exploitation of his apparatus, and the constructive work of obtaining and assimilating his results. Although the laws involved are simple, this means the correlating of numerous quantities, namely, length, area, nature and quality of the wires tested and their resistances and resistivities under various degrees of tension and temperature.

This is work which will involve considerable time if properly done. Had the student spent the same time doing four or five routine experiments instead, with the handing in of four or five routine reports, would he have accomplished anything like as much? The fact is, he is spending extra time on this work because he likes it. Is it not reasonable to expect that a year of well-chosen problems of this kind will do much toward making an enthusiastic and intelligent investigator of him? I regret, of course, that the possibilities are limited by the lack of available time in so crowded a course as that of our junior electricals. What I wish to do is to be able to carry forward the theoretical investigation which is opened up and started by such practical problems in the laboratory.

Sometimes it is quite as desirable to have two students work together as to have them separated. In such cases they should be equally self-reliant. Then they can discuss and plan out their work, and they can work faster on constructing apparatus and computing results. I have been grouping men in pairs but have often separated them from time to time, especially where one of a pair had a tendency to lean on the other. Here is an instance of two men working together in harmony. I assigned them an experiment in calibrating direct current voltmeters and ammeters. Besides learning general methods and our particular arrangement of circuits and apparatus for this work, they were to study the principles of action of the meters.

Then I gave them an old meter which happened to be on hand. It had a large scale and was intended for vertical mounting. I thought it could be used to advantage in connection with demonstrations if it were put in working order and properly mounted. Well, they have now been working on that meter for two weeks. It seems as though they had learned all about its internal arrangement, its delicacy of adjustment, various precautions that must be taken to get results, and in fact they have achieved a degree of competency in handling that class of instrument which ought to remain with them and be readily extended to other work they will do later.

I would not give every member of the class an old meter to work with. In this instance it has made a successful individual problem for each of these two men who have puzzled, studied and labored over it. When finally mounted, calibrated and made to appear as presentable as possible, it should be a useful addition to our equipment and a source of some satisfaction to the students who worked upon it. Many similar instances could be given to show the large amount of what must rightfully be acknowledged to be creative work that is being done by these juniors. It must be borne in mind that they are having their first experience in electrical work, except for the small amount of electricity given in their sophomore physics course.

I will give one more instance for the sake of making my story more general. Two students were assigned to study the incandescent lamp, especially with reference to its electrical resistance and temperature coefficient. They started by reading up on the subject of lamp construction and manufacture. The first experiment was with a carbon lamp under variable impressed voltage. To their surprise they found the lamp to have a positive temperature coefficient of resistance instead of negative, as commonly assigned to carbon. On investigation, they found their results to agree with those given for the metallized carbon filament and this was what their lamp proved to be. Then they wanted to try an old type carbon lamp to see if they could get the negative coefficient. Also they tried tungsten, and the enormous change of resistance offered by this metal in going from cold to hot was of lively interest. We also found a tantalum lamp and a carbon lamp which had lost its vacuum. Altogether there was quite a good variety.

The next step was to try to obtain experimental verification of some questions I gave them relating to series-parallel circuits made up of lamps. For instance, one lamp in series with two in parallel—if they are alike and double voltage is impressed, will the lamps operate acceptably? This question was answered theoretically, and many similar questions. For the experiment, they wired up a small board with three lamp sockets. It was unnecessary to apply double voltage and burn out some lamps, for the relative brilliancy was just as acceptable on reduced voltage. They noticed that when a carbon lamp and a tungsten lamp are in series, on closing the switch the former lights up at once while the latter comes up slowly to its final brilliancy. The effect was very pretty and they were interested enough to discover the reason for it themselves, which they were able to do with the help of their experimental data.

But with all this experimenting with lamps they began to feel that they were after all missing the main point by not making tests of illumination. Now it happens that we have no photometer in our laboratory. But, a few years ago I had had two seniors design and construct an illuminometer as thesis work. This apparatus had been very successful. We also had a class room which was inadequately lighted, the result of unfortunate arrangement of the lights rather than an insufficient number of them. So, I gave the boys this problem: they were to measure the illumination of this room with the illuminometer, in the meantime studying up the fundamental principles of illuminating engineering.

Then they were to plan out changes, make them and compare results. They have put in many evenings on this work during the past four weeks. At present the room is very finely illuminated, although the work upon it is not yet quite completed. Anyone may be seated in it at random and be sure of listening to the lecture without subjection to the slightest inconvenience due to the lighting. The blackboard behind the speaker is brightly illuminated, and there is enough general diffusion about the room to permit of the taking of notes by anyone in the audience. Moreover, under the old arrangement the power consumed was 1000 watts, while now it is but 700 watts, making a saving of 30 per cent., a small item, but one which ought to be appreciated by the college administration.

The next logical step is the photometer. Whether or not it will be best for me to put these two students on the problem of designing and constructing a photometer remains to be decided. Their work ought to be kept properly balanced. At the same time it must be acknowledged that they have learned a great deal besides illumination since they began on the incandescent lamp a month ago. If they really desire to make a photometer, I shall, in all probability, let them do so, and with all my heart, because my whole scheme falls completely to the ground when I fail to regard the student's interest.

But now, with the above incidents in mind, someone may ask: ''Do you really attempt to apply this method to all students in the electrical laboratory?'' I answer, ''assuredly, I do. It is the general laboratory method.'' Students do not always respond with enthusiasm, it is true. They have been trained for years not to be enthusiastic about their educational work. But I had one, last year, who dropped out shortly before the Christmas holidays. He was a fine fellow, tall, athletic and with a good head on his shoulders. I hear that he is now a United States officer serving his country ''somewhere in France.'' As a student, he was pretty much of a failure, and undoubtedly he was, himself, largely to blame.

But he told me, shortly before leaving college, that his laboratory course was the only work he had had in more than two years of college that had interested him in the slightest degree. To instill interest in such students is by no means an easy task. This is not a reflection on the instructors, for the very best of them recognize the difficulties inherent in our present system, in this respect.

The work I have described relates to juniors. With seniors it is somewhat different the way I am doing it now. This is because I consider it very important to train the juniors carefully in the way they ought to go, while the seniors, having been already trained, may be trusted to work to a large extent upon their own initiative or at least without a great deal of supervision. I have two seniors assisting me with junior work but no assistance with senior work. In fact, under the pressure of theory and other courses the time available for extensive senior laboratory work is insufficient to permit of very much departure from the usual experiments with electrical machines. Nevertheless, the method certainly does apply also to seniors. Each group of two or three receives its assignment of work individually from me. Always there is the likelihood that something special will develop and give a particular interest to the experiment. My conception is that the theoretical side of the work should grow more and more in importance with the increasing knowledge of the student, and that seniors should naturally spend less time than juniors on the more mechanical side of laboratory work. But I should like to have the theoretical work of seniors as well as juniors emanate largely from the laboratory.

Possibly there is enough food for thought in what has already been written. There are, however, a few more things that should be said and that ought to be borne in mind by anyone who attempts to appraise this system. The ideas are being, at present, very imperfectly carried out for several reasons. One reason is that no readjustment between the laboratory and other work of the course has been made with a view to giving the laboratory a dominating position with respect to the students' theoretical studies. This naturally places a limit on the amount of expansion possible to the laboratory, which is determined mainly by the available free time of the students.

Another reason for limited results is that there has been, as yet, no attempt to give this method proper setting in the electrical course as a whole. Such a setting, it has seemed to me, would call for the admission of students to work in the electrical laboratory in the sophomore year if not earlier. Where a good share of mechanical work is included there is much that could be done by freshmen or sophomores just as well as by juniors. This would lend interest to their work and they could easily be required to maintain a higher standard of accomplishment than now generally exists.

It appears that some rearrangement of the course would be necessary as respects non-engineering subjects. These need by no means be subject to curtailment, but possibly would be advanced somewhat so as to spread along over the whole course instead of being concentrated in the first two years. In the electrical laboratory, juniors would be far more advanced and proficient than at present, and seniors still more so. Stress would then be laid upon creative work all along the line.

I realize that considerable burden would rest upon the laboratory instructors. But then the entire electrical department would be concerned primarily with laboratory work. Right here also is one of the most important features of the whole plan. We should utilize a large number of student assistants. It is well known that a student who is assisting learns a great deal from this work. It would therefore be beneficial to employ quite a large number of seniors to assist with juniors, sophomores and freshmen, and in some instances juniors also might be appointed to assist with the lower classes.

If there are graduate students a few of these would naturally be available to act as assistants with the senior work. The professor's work would then be largely to originate problems and supervise assistants. But he would also keep in contact with all the work going on in the laboratory and confer frequently with individual students, stimulating their interest and coöperating with them in the various stages of the work.

In my present situation it is not possible to give over as much routine work for work of the higher order as I should like, and consequently I can hardly expect to get the maximum of good results. Supervising the laboratory work of about fifty students with the help of two senior assistants naturally keeps us all pretty busy. Nevertheless, I should hate to go back to the old routine list of experiments. The individual problem certainly lends itself to the stirring up of interest as no routine program can ever hope to do. There are a hundred ways of verifying Ohm's Law; why should we limit ourselves to one prescribed way in the laboratory?

This, then, is my new point of view in laboratory work; the professor, an originator of problems, experiments and ideas, a corps of student assistants drawn from the upper classes, guiding, and helping to create an atmosphere of research among those they are assisting, and finally, the individual student working upon his own problem, creating, experimenting, analyzing and generalizing. The laboratory thus leads into the theory, and dominates it. We progress, as heretofore, from the simple to the complex, but in addition to that it is now also from the concrete to the abstract, from the particular to the general. This, it seems to me, lies at the foundation of the question of how we are to educate capable scientific investigators and engineers in America.

TECHNICAL ENGLISH.

BY J. H. ATKINSON,

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I. *Standards of Scientific and Literary Composition.*—In much discussion of technical writing there is the danger of creating the impression that it is governed by a set of principles peculiar to itself. If there is a boundary between technical and literary composition it is hardly in any essential respect that would entail a special method of teaching. Technical and literary English may be regarded as two different fabrics which are woven in the same loom. The warp and woof of the one does not differ from that of the other; but the fabric may have the sturdy quality and the loose finish of a woolen, the compactness and the gloss of a fine linen, or possibly the composite nature of a linsey-woolsey. The loom is impartial in its contribution. The method is unchanged. The differences in the finished products lie mainly in the quality and nature of the raw material.

But the quality of the student's mind accounts largely for the presence or the absence of a literary flavor in his composition work. Literary virtue is largely a color of the mind which gets itself represented in language, pretty much as humor, or satire, or wit lends a flavor to a piece of writing without affecting the rules of structure which are common to technical and literary composition. Literary expression is sometimes thought to be a matter of aptitude, perhaps even a matter of ancestry. A given subject, or possibly any subject, may be given literary treatment, but only by a writer with a literary turn of mind.

Technical English is more especially applicable to facts and is likely to be more or less formal; literary English is especially applicable to truths and is apt to be more or less imaginative. The one most often makes an intellectual, and the other an emotional, appeal. If we ask of Mr. Peele's treatise on the "Compressed Air Plant" and of Mr. Howells's novel called "The Rise of Silas Lapham," Are they true? we shall have to say that they are. The one is true to scientific fact and the other is true to human nature. But when we have read the treatise we are in possession of the facts, and so it has no power to allure us back to it. When we have read the novel we are likely to be so pleased with its emotional appeal as to go back to it again for a renewal of the emotion; and with each re-reading we are likely to discover some new phase of truth with its attendant emotion. The permanency of knowledge renders the treatise of merely ephemeral interest: the transiency of emotion makes of the novel a permanent delight. The novel is to be absorbed and interpreted rather than read and remembered. The power it has to bring one back to it again and again is its title to literary quality. And so Mr. Peele, once read, has delivered his message, except as he may have availed himself of any opportunity to impart to his composition a literary flavor. Mr. Howells, on the contrary, is likely to be of permanent interest.

Technical writing, in other words, seems to be specific rather than general, objective rather than subjective, matter-of-fact rather than imaginative. It bases its worth on the information it gives, provided the information be copious and accurate and so orderly in its presentation as to be readily understood. It concerns itself with that about which definite statements are to be made and provides a minimum of opportunity for imagery, for word-painting, or for the play of the fancy. It makes use mainly of a terminology that carries a prescribed and well-understood meaning, and does not commonly employ a word that has associations apart from its accepted definition and use. It carries a minimum of implication, or of matter to be read between the lines, or interpreted by the reader depending upon his imaginative and emotional nature. In other respects the technical writer is on a common ground with the literary artist.

But so unencumbered with any literary intent is the average student of technical composition that he is entirely willing to waive his right to be interesting in favor of the interest that is naturally inherent in the subject matter. His facts are too little likely to be enlivened by his sympathies, brightened and vivified by his imagination, or made picturesque by skilful use of language. He causes the instructor no apprehension in the direction of literary dash, but lays upon him the task of imparting a respect for a well-chosen word, a well-groomed sentence, and a well-built paragraph. He seems to nurse an aversion to a legitimate use of pronouns, participles, particles, and parallel construction. Yet, in his observance of the points covered by this alliterative group of terms is his chief hope of acquiring an adequate style of writing.

II. *Standards of Structure.*—Although any given flaw in language may of itself seem unimportant, yet, like a loose joint or a maladjustment in a machine, it is certain in some degree to hinder its efficiency. Niceness of adjustment and smoothness of movement are the last and subtlest indications of power and efficiency in language. Mere authority for the use of a given form of expression weighs light beside the necessity that the language deliver its freight of thought with certainty and without depreciation. The language must not be liable for damages inflicted upon the thought in transit. Facility with the vehicle of thought comes, aside from a matter of aptitude, from an acquaintance with a few devices of manipulation. To ride a bicycle or to shade a drawing baffles one till he learns the trick. It is even so with the smooth and certain conveying of a thought, which is conditioned largely upon the correct use of *parallelism, verbals, reference,* and *connectives.* These are the fundamental points, and they need only to be examined with some degree of respect to yield up their secrets. They are a common source of uncertainty to the writer who has not taken the pains to examine them in detail.

PARALLELISM.

To get a clear view of parallelism in language, let us first look at the Panama Exposition. The sameness in architectural design was the means of putting the buildings into one family, and the uniform smoked ivory effect in the color scheme completed the blending of the composite city into a unit. Or again, look at the farmstead in which all the buildings are of the same material and painted the same color. Look at the regiment in uniform or the choir in costume. Uniformity on the part of the coördinate members emphasizes the unity of the group. To give unity to a structure, whether it be called a house, a human character, or an English sentence, there must be consistency, or uniformity, especially with regard to the treatment and the aspect of the like parts.

Uniformity is a cloak that covers a multitude of errors. The statement might well be a proverb, so widely extended is its application. It is applicable to the organization of an army, or to an allied attack upon an enemy. It is applicable to the building of railway cars or of road-wagons, to the manufacture of plows or of window-sash, or to the laying of a conduit-pipe. It is as true of a sentence as of a gas-main that the parts which are similar in purpose must be similar in form, to enable the commodity to be delivered to flow unencumbered and without leak. The following sentence, for instance, violates the principle of uniformity in the similar or coördinate parts and so encumbers the flow of the thought: "The first Watson life-boat had low end-boxes, not for righting purposes, but in order to decrease the space that could be filled by shipping a sea." The supposed reason and the real reason for the low end-boxes are the two similar or coördinate parts of the thought, and they should be expressed in similar language. But in the sentence, as written, the one is expressed with the prepositional phrase *for righting purposes* and the other with the infinitive *to decrease*. It is as though the right wing of the Capitol were built of red granite and the left wing of buff brick. Express both the reasons for the low end-boxes in the same form of language and note the swiftness with which the sentence delivers its thought: The first Watson life-boat had low end-boxes, not *for righting purposes,* but *for decreasing the space that* could be filled by shipping a sea.

The "and which" and "but which" error arises from the neglect of this same principle of parallelism: "There are some other rays given off in a similar way, along with the Röntgen rays, *but which* are not Röntgen rays." The coördinate conjunction *but,* or *and,* or any other coördinating conjunction, joins elements of thought which are coördinate and which consequently require similar language. As the conjunction *but* in the sentence is followed by a relative clause we naturally look to see it preceded by a relative clause. Vice versa, as it is preceded by a participial phrase we naturally look to see it followed by a participial phrase. In other words, the participial phrase *given off in a similar way* is balanced over against the relative clause *which are not Röntgen rays.* Note the good effect of making the conjunction to balance two relative clauses: There are some other rays *which are given off* in a similar way, along with the Röntgen rays, but *which are not Röntgen rays.* Or two participial phrases: There are some other rays *given off* in a similar way, along with the Röntgen rays, but *not recognized as Röntgen rays.*

In the following sentence one of the two coördinate ideas is expressed in a participial phrase and the other in an independent statement: "We found other bones and teeth, *some* evidently *belonging to a stout and heavy animal,* the *others suggested* an animal of lighter build." *Some* and *others* are the bases of the two coördinate ideas, and for effectiveness one should express what he has to say about *some* and *others,* respectively, in parallel statements: We found other bones and teeth; *some* evidently *belonging* to a stout and heavy animal, and *others suggesting* an animal of lighter build.

VERBALS.

The term *verbal* is merely a general name for some three or four forms of speech, which either name or express the action, but which do not predicate anything of a subject. Having no office, therefore, as finite verbs, they are sometimes called infinitives. But as one of the four forms is commonly known as an infinitive, the term verbal obviates the danger of confusing the genus with one of the species. The four forms are, the *gerund,* the *participle,* the *verbal noun,* and the *infinitive.* Only the gerund and the participle are included in this discussion; any noticeable misuse of the other two forms in the books I have read is entirely negligible.

The *gerund* has an honored ancestry and a firm place in the language. In endless variety it is found in the best literature. Its misuse, however, in the technical and scientific writing examined for this paper has seemed excessive. Its legitimate use in certain of the books which I have read would have redeemed the language from a second-rate quality and made it unimpeachable.

The gerund is a verb-form ending in *ing.* Although it expresses action it makes no affirmation of a subject; yet the action must necessarily have reference to a definite subject, which must be expressed. Verb-form that it is, the gerund is invariably used as a noun. Example: "He acquired his aptitude in expression by *attending* to the subtleties of language." The gerund is distinguishable from the present participle, with which it is identified in form, by the fact that the participle has an adjectival function and invariably limits a noun or pronoun. Example: "*Attending* casually to the niceties of language, he unwittingly acquired an effective style of expression." In the following sentence the participle is substituted for the gerund with the result that the statement of the thought is illogical: "They did not take into account the possibility of the earth *being* a self-heating body." The thought establishes the word *being* as the object of the preposition *of,* and hence makes it a gerund. In the language of the sentence, however, *being* is used as a participle to limit *earth*, which in turn is wrongly made to serve as the object of the preposition. In other words, *earth*, which ought to be reduced to an adjectival form to limit the gerund *being*, has been made the subject of the participle *being*. The adjective and the noun have been made to exchange functions, with the result that the writer, who evidently meant *the possibility of being*, has said *the possibility of the earth.* The sentence should read thus: They did not take into account the possibility of the earth's *being* a self-heating body.

If the gerund is preceded by a pronoun the mistake of reducing the gerund to a participle is never made. For instance, the following three sentences, which were written in consecutive order, reduce the gerund to a participle when it is preceded by a noun, but recognize its legitimate use when it is preceded by a pronoun: ''There was trouble with the *hammer getting* off the handle.'' ''But he hit upon an improvement which led to *his being* able to put a hammer upon a handle in such a way that it would stay there.'' ''With this improvement,—there is no danger of the *head flying* off.''

A popular misuse of the gerund is the omission of its subject: ''On *sending* the spark from the induction coil through the tube the little wheel is driven round.'' The writer did not intend the reader to understand that the sending was done by the wheel, and yet the logic of the language distinctly says that it was. It is better in this sentence not to use the gerund, as there is nothing gained by introducing its subject. The statement might be phrased thus: When the spark is sent from the induction coil through the tube the little wheel is driven round. Or it can be phrased as follows: On the sending of the spark from the induction coil through the tube the little wheel is driven round.

The use of the *participle,* as well as of the gerund, without an expressed subject is very common: ''Now *throwing* a beam of ultra-violet light upon the disk, the leaves are seen to collapse rapidly.'' The logic of the language, as a matter of fact, makes *leaves* the subject of the participle; but the writer did not intend to say that leaves throw a beam of ultra-violet light. As there is no need of introducing the subject the participle should not be used. The sentence could be written thus: When we throw a beam of ultra-violet light upon the disk the leaves collapse. Or, if the participle is insisted upon its subject must be expressed: Now *throwing* a beam of ultra-violet light upon the disk, *we* cause the leaves to collapse.

Akin to the gerund and the participle which have no expressed subject to attach themselves to is the dangling elliptical clause. Although it has no part with verbals, nevertheless it is due to the neglect on the part of the writer to provide each term indicating action with an expressed subject: "*When utterly disheartened* I have encouraged the boy." Whether *I* or *the boy* is disheartened can not be determined without help from outside the sentence. The logic of the language makes *I* the subject of disheartened; the general presumption, however, would be in favor of *the boy* as the subject. In that case the thought might be expressed thus: When the boy has been utterly disheartened I have encouraged him. A subordinate clause should not be made elliptical unless its subject is the subject of the clause which it limits. The following use of the elliptical clause is entirely legitimate: *When entirely disheartened* he still put on a good front.

Reference.

Reference words skilfully used are clearly labor-saving devices in the language machine. Misused, they throw the machine out of gear. The pronoun, chief of the reference words, requires pretty careful handling. It refers specifically to a definite word; and any attempt to cover larger ground in its reference, or any use of it that admits two possible references, inevitably results in disjointure in the language. In case it can not have a specific word for its reference there is no call for its use. To introduce a pronoun, for instance, when the thought requires a conjunction is illogical: "Bolton asked Watt to act as his attorney, *which* he did." Substitute *and* for *which:* Bolton asked Watt to act as his attorney, *and* he did. Again: ''When the paint dried, *which* it soon did, he completed his toilet.'' When the paint dried, *as* it soon did, he completed his toilet.

It is illogical to introduce a pronoun as substitute for an antecedent which has not been expressed: ''The wood ought never to be varnished, for *it* gives a common look to the article.'' Drop the pronoun and use the noun instead: The wood ought never to be varnished, for *varnish* gives a common look to the article.

The reference must be single, and not ambiguous: ''Here the Rockies are not in the least like those crossed by the Union Pacific—so modest and uneventful you scarce know where *they* begin or leave off. You can put your foot on the very spot where *these* begin.'' *They* refers with impartiality to the Rockies in both places. *These* likewise. The ambiguity produces mental dizziness. But the general looseness with which the comparison is drawn between the two sharply contrasting situations accounts for the failure of the language to deliver its thought effectively and with precision. The problem here is not so much one of reference, however, as of parallelism. Here is the writer's opportunity to try out the devices of parallelism and balance, for accuracy of portrayal and for telling effect. The two parallel situations with opposite characteristics require parallelism in phraseology and a careful balancing of one item against the other: Here the Rockies are not in the least like those crossed by the Union Pacific: here you can put your foot on the very spot where they begin; on the Union Pacific they are so modest and uneventful you scarcely know where they begin or leave off.

CONNECTIVES.

The following is an illustration of the common misuse of reference words that seem to partake of the nature of both conjunctions and adverbs: ''The dwellers in the intermediate region were better provided with vegetable food, *yet* they needed supplies of winter food.'' *Yet* is a kind of hybrid—a cross between a conjunction and an adverb. But its conjunctional office is only a shadowy and unsubstantial one and in the grammar of the sentence is entirely lost. Its function is invariably that of an adverb. In the sentence above it is used apparently as a subordinate conjunction to introduce the clause *they needed supplies of winter food*, and to limit the verb *were provided.* An analysis of the sentence shows *yet* to depend upon the verb in the clause which it introduces; but an analysis of the thought discovers the subordinate part in the words *they were better provided with vegetable food.* The following sentence adequately expresses the thought: The dwellers in the intermediate region, although they were better provided with vegetable food, yet needed supplies of winter food. If *yet* were preceded by a semicolon all suspicion of its use as a subordinate connective would be at an end, and no other charge could be brought against it: The dwellers in the intermediate region were better provided with vegetable food; *yet* they needed supplies of winter food. Or the period would serve as well: The dwellers in the intermediate region were better provided with vegetable food. Yet, they needed supplies of winter food. Or the comma may be retained if the coördinate conjunction *and* is introduced to lift the conjunctional office from the shoulders of *yet:* The dwellers in the intermediate region were better provided with vegetable food, *and* yet they needed supplies of winter food. *Yet* is typical of a group of words whose use is identical and whose office is commonly misunderstood. They are: *so, therefore, then, hence, still, nevertheless, however, furthermore, moreover, accordingly, otherwise, also, besides,* and possibly one or two others.

In conclusion it might be of interest to state that the error most commonly met with in the reading of technical and scientific books is the misplaced *only.* Pride of workmanship joins with logic in demanding that *only* and her sister words receive accurate placement. Technical writers seem largely to meet this demand with indifference. The writer of the following sentence impaired his reputation for precision of statement, and momentarily confused his reader, by failing to shift *only* to a position after *connected:* "There was a flat flooring, only connected by pins and bars with the closed side of the boat." The writer of the sentence has failed to realize what he has said: the statement betrays that the writer was not keenly alert to the virtue of clear thinking or of precise statement. The difficulty, of course, is that *only* may be attached to words, phrases, and clauses as well as to substantives, verbs, and adverbs. Like the infinitive, it becomes elusive in the variety of its applications. In the sentence, "The discussion of the most important point can *only* come up after the next chapter," *only* has been allowed to stray away from its principle, which is the phrase *after the next chapter,* and to have its relationship usurped by the verb *come.* The sentence as written means that the point can do nothing except come up after the next chapter. The intended meaning is that the point can come up after the next chapter, and at no other place. Although the illogical use of *only* borders closely upon the ridiculous, yet the use is common. In the logical use of *only,* however, the writer's habit of close thinking is first established: in it is the measure of his intellectual uprightness in his dealings with the English tongue.

There is possibly not so much of uncertainty on the part of the writer regarding the language devices treated in this discussion as of incomplete realization of what he has actually written. Although some of the devices are more or less elusive till one has "nailed" them, so to speak, yet one has only to look at them a second time to recognize their logical force and their title to respect. A modest submission to their behests is the sign manual of standard composition: ignoring them clogs the machinery of language; yielding them a respectful degree of conformity makes for power and efficiency in expression. To attend to the necessary revision of language contemplated in this discussion is to redeem from the category of flabby and ineffective writing a composition that may be sound in purport and valuable in content. The prevalence of illogical statements in works of otherwise high merit suggests the rich return that careful revision may yield. The structural readjustments for language efficiency, such as are here exemplified, is the kind of thing for which the technical man is peculiarly fitted by virtue of the type of training he receives.

III. *Standards and the Student.*—In the matter of language expression the American student of technology is setting his standard too low to meet the requirements of his profession. No one knows better than the technical man himself, when he gets out into the stream of things, how exacting are those requirements, and how dearly he pays for his lack when he can not meet them. For instance the Alumni of Tau Beta Pi recently insisted to a man that the undergraduate engineer be provided with more and fuller instruction in English, as reported in *The Bent* for April, 1916. The technical student, especially during his first years in college, is likely to make inadequate preparation for the practical use of his language; and any special study of composition that may be urged upon him he is likely to resent. With this attitude toward the study of English perhaps it is not strange that he should regard his teacher of English as something of a visionary and pretty much out of sympathy with practical things. The lure of the practical and the immediate is strong upon him. His choice of a technical college implies that he is eager to be about the tasks of life and chooses to pursue only the so-called technical studies necessary to his profession. In this frame of mind he would regard a study of currency as useless to one who already knows the denominations in which it is issued; and for one who has long known the names of things language-training seems to him superfluous. At a time when there is so much active practice with instruments and materials to claim his attention it is not strange that he is likely to feel a little ashamed to be juggling, like a schoolboy, with the elements of speech. Movement, activity, and a large range in the laboratory and in the field are likely, from his present point of view, to outweigh in value any mental gymnastics that the study of language imposes. He has not yet reached that point of vantage where the architect is seen as the peer of the builder, or the engineer with a sharp pencil as taking precedence over the engineer with a transit, or the man at the desk, who dictates the letters and the drawings and the specifications, as the one in command. In short, the student of technology is likely to overlook the importance, in his chosen field, of a mind trained to marshall ideas and give them apt and adequate expression.

The problem would seem, therefore, to be one of attitude and point of view. It would be so especially at the start. Efficiency in his work, success in his profession, or well-being in his life is conditioned on the education of his mind—of this the serious student of technology usually is convinced. Often, however, he is not aware that the education of his mind is conditioned upon his point of view. His point of view may be that of one who expects to be only a hireling, or possibly only a mechanic; or he may have the point of view of one who expects to be nothing less than a leader in his profession. He wishes, of course, to have credit—and to deserve it—for discrimination and good judgment. There is no high power of discrimination necessary to judge between sand and salt; but to discriminate between prejudices, presumptions, and personal conveniences on the one hand, and the big things of life on the other, is of tremendous importance. If the student takes the view that such discrimination is necessary, the education of his mind will take care of itself; otherwise his point of view will be his undoing. If in his writing and speaking, as in his figuring, he holds himself to the facts and to correctness of form and method, his point of view is sound and will result in a habit of clear thinking. Indeed, he is not safe until he is positively of the temper of mind to consign clumsiness, indefiniteness, and ambiguity of language to the discard of profanity, dishonesty, and soiled linen. Whether he is paid a debt, or pays it, he is to insist on its being paid adequately and not approximately. Whether he writes or reads he is to insist on accurate and adequate expression. As an engineer he would not accept in a finished structure a mere approximation to his mechanical design; neither can he afford, as a builder of language structures, to be content with an ambiguous or an illogical expression of his thought design. A technician is nothing if not accurate and adequate not only in his structures but also in his drawings, reports, specifications, and contracts.

Even after he has acquired the temper of mind and the point of view, still he is encumbered with the handicap of inexperience. He who has not yet had experience with practical life is in a difficult position to acquire a standard that is practical. Without experience it is difficult for him to get a vivid impression of the practical lines upon which business generally proceeds, of the points that rule in the professions, and of the social forms that carry in the psychology of commerce. Without experience it is difficult for him to see that the echo he gets from the world is the reaction of his own personality, and that it is a positive, clean-cut, and definite personality that gets quick and strong and favorable response. Of course, the student cannot fully know without experiencing. But much may be done to help him to anticipate. He is to be encouraged in the idea that the ethics of his profession concern themselves largely with matters of appearance and language and conduct, and in a wholesome respect for conservation and balance, sanity and proportion, discriminative judgment, and the power to recognize what is fair and good. With the lure of the efficient mind will certainly come the revelation that mere conformity to the technical principles underlying his profession is by no means the sum of the observances he will be expected to make. And along with this wider range of concerns, he is to be especially encouraged in the idea that he can ill afford to ignore the need of perfecting himself in the use of the language.

REGULATIONS GOVERNING ENLISTMENT.

It became evident about the first of December that energetic measures must be taken by this Society to do everything it could to secure a ruling from the Provost General in regard to enlisting engineering students in the Enlisted Reserve Corps so that they might finish their course before entering active service. The following committee, consisting of G. C. Anthony, F. L. Bishop, S. P. Capen, Robert Fletcher, Hollis Godfrey, J. F. Hayford, Ira N. Hollis, C. S. Howe, D. C. Jackson, M. S. Ketchum, F. W. McNair, C. R. Mann, Mansfield Merriman, W. G. Raymond, C. Russ Richards, G. F. Swain, W. M. Thornton, and F. E. Turneaure, was appointed by President Ketchum and met in New York City on December 6 in connection with the annual meeting of the American Society of Mechanical Engineers and the Council of the Engineering Societies. As a result of this meeting, President Ketchum, Professor Swain and President Howe were appointed a committee to present resolutions which were drawn up and passed at this meeting, to the Secretary of War. They proceeded to Washington and discussed the subject at length with various officials of the War Department. The committee was fortunate enough to have the assistance of Dr. Mann who was called to Washington at this time. This committee has been made a permanent committee of the Society. As a result of the agitation in regard to the subject the following regulations have been issued:

War Department
Office of the Chief of Engineers
Washington

December 15, 1917.

REGULATIONS GOVERNING ENLISTMENT BY ENGINEERING STUDENTS IN THE ENGINEERING BRANCH OF THE ENLISTED RESERVE CORPS.

1. The Selective Service Regulations have recently been modified by inserting the following:

Under such regulations as the Chief of Engineers may prescribe, a proportion of the students, as named by the school faculty, pursuing an engineering course in one of the approved technical engineering schools listed in the War Department may enlist in the Enlisted Reserve Corps of the Engineer Department and thereafter, upon presentation by the registrant to his local board of a certificate of enlistment, such certificate shall be filed with the Questionnaire and the registrant shall be placed in Class V on the ground that he is in the military service of the United States.

2. In accordance with the authority given by this modification of Selective Service Regulation, the following regulations are promulgated governing the enlistment by engineer students in the Engineer Enlisted Reserve Corps.

3. In order to be eligible for enlistment in the Engineer Branch of the Enlisted Reserve Corps under the above-quoted amendment to Selective Service Regulations, a candidate must fulfill the following conditions:

(*a*) He must be a citizen of the United States.

(*b*) He must be a student in one of the schools, the names of which are borne upon the list of technical schools approved by the Secretary of War for the purpose of carrying out Section 5 of the River and Harbor Act approved February 27, 1911, relating to appointments from civil life to the grade of second lieutenant in the Corps of Engineers.

(*c*) He must be regularly enrolled and must be pursuing a course required for the degree of chemical engineer, civil engineer, electrical engineer, mechanical engineer, mining engineer or some other equivalent engineering or technical degree.

(*d*) He must have made, since his entry upon this course at the school, a record of standing which will indicate clearly that he may be regarded fairly as deserving a place among the first third, based primarily on the scholastic records, of the young men who have graduated from that institution during the past ten years.

4. Each candidate for enlistment must submit an application made out in his own hand and in the following form:

....
(Place)

..............................19..
(Date)

THE CHIEF OF ENGINEERS, U. S. ARMY,
WAR DEPARTMENT,
WASHINGTON, D. C.

Sir: I hereby apply for enlistment as a private in the Engineer Enlisted Reserve Corps of the United States Army. My full name is
.... I was born on
(full name without any abbreviations whatsoever)
.... at .... I am a
(date of birth) (place of birth)
citizen of the United States by $\left(\begin{array}{l}\text{birth}\\ \text{naturalization}\end{array}\right)$. I am a student at
.... and am in my .... year and am
(name of institution)
pursuing a course in ....
(course which candidate is pursuing)
and am a candidate for the degree of................................
(degree for which candidate is working)
.... My home address is ....
(street) (city)
....
(state)

Very respectfully,

(Signed) ....

(School address) ....

5. Each application must be accompanied by a certificate from the president or dean, *carrying the seal of the institution and made under oath* before a notary public or other civil officer authorized to administer oaths, in the following form:

I hereby certify that .... is a
(full name of candidate)

regular student, in good standing, at ....
(name of institution)

and is pursuing the .... year of
(1st, 2d, 3d or 4th year)

the course, in ...., and is
(course which candidate is pursuing)

a candidate for the degree of ....
(degree for which the candidate is working)

....

I further certify that in the judgment of the faculty of this institution, as indicated by the academic records, supplemented by his relations with his fellow students and by observation of his instructors, he may be regarded fairly as deserving a place, qualitatively, in the first third of the young men who have graduated from this institution during the past ten years.

....
(signature)

Sworn and subscribed to
before me, this ....
day of ...., 191... (office held at institution)
(Notary's seal) (Seal of Institution)

6. In order to receive prompt consideration, applications from candidates now at college, and who are over twenty-one years of age, should be submitted so as to reach the office of the Chief of Engineers in Washington not later than January 15. The application from a person who has not reached this age at the present time must be submitted within three months before, or one month after, he reaches the age of twenty-one.

7. As rapidly as possible after the receipt of the applications in the office of the Chief of Engineers, they will be carefully examined, and the candidates whose applications are approved will promptly be sent cards of authorization, authorizing them to be enlisted in the Engineer Enlisted Reserve Corps by an officer authorized to make enlistments in the Army, provided, of course, that they pass the necessary

physical examination which will be immediately prior to enlistment.

8. When thus enlisted the student's name will be placed on the "inactive list" of the Engineer Enlisted Reserve Corps, and he will be allowed to remain on this inactive list in order to enable him to complete his course at the institution.

9. Immediately after the completion of this course, or upon his discontinuance of the course for other reasons, the student will be given the option of being called into active service under his enlistment and being assigned to some one of the engineering branches of the Army, or of being immediately discharged and taking his place again among those subject to service under the draft.

W. M. Black,
Major-General, Chief of Engineers.

Approved:
Newton D. Baker,
Secretary of War.

COMMUNICATION RELATING TO THE RECENTLY ISSUED REGULATIONS GOVERNING ENLISTMENT BY ENGINEERING STUDENTS IN THE ENGINEER BRANCH OF THE ENLISTED RESERVE CORPS.

To the Heads of Engineering Schools:

The regulations permit high-grade work at an engineering school to be classified as a branch of the military service of the United States. The honor of enlistment in the Enlisted Reserve Corps of the Engineer Department is extended to all engineering students, who in the opinion of their faculties are reasonably certain to become successful engineers. The proportion of the students to whom this privilege is granted is not fixed but must be determined by each school on the basis of its experience and in accordance with its best judgment. Under these conditions it is expected that the schools will appreciate their opportunity and administer the regulations conscientiously.

To this end the undersigned committee of the Council of National Defense makes the following suggestions:

1. The "first third" mentioned in the certificate on page 3 of the regulations does not apply to any one class but to the graduates of the school by whom the standard is set. In a poor class it may happen that less than one third can be recommended for enlistment; in a good class, on the other hand, more than one third may be recommended. The entire responsibility of deciding which men are to be recommended rests with the faculty of the school. It is evident that this is a very elastic regulation. The committee, however, ventures to point out that it will not be advantageous to an institution to include among the candidates that it recommends the names of any men who probably cannot be admitted on account of physical disqualification or of any whose promise of usefulness as engineers is, in the judgment of the faculty, doubtful.

2. Schools are advised to require each candidate to take the physical examination given by the local board immediately and not to issue the certificate prescribed in paragraph 5 of the regulations until the candidate has passed the physical examination.

3. The provisions for eligibility for enlistment in the reserve corps prescribed in paragraph 3-C apply only to resident students.

4. Paragraph 3-C applies to students pursuing courses leading to the degree of B.S. in any of the engineering branches, as well as to those pursuing courses leading to the degrees mentioned and to those students in residence pursuing graduate courses leading to these and other higher engineering degrees.

5. Paragraph 5 of the regulations mentions three different things, all of which should be taken into account in selecting the students who may enroll in the enlisted reserve corps; namely their academic records, their relations with fellow students and the personal observations of their instructors. The War Department has adopted an effective method of rat-

ing candidates for officers' Training Camps on their personal qualifications. A copy of circular C. C. P. 201 explaining this method is enclosed.

6. The regulations state in paragraph 3-B that in order to be eligible for enlistment in the engineer branch of the Enlisted Reserve Corps a student must be enrolled in one of the schools "the names of which are borne upon the list of technical schools approved by the Secretary of War for the purpose of carrying out Section 5 of the River and Harbor Act, approved February 27, 1911, relating to appointment from civil life to the grade of second lieutenant in the corps of engineers." The list referred to is not to be published by the War Department. If the officers of an institution are uncertain as to whether the institution is included in this list, they are advised to inquire of the Chief of Engineers.

7. President Wilson and Secretary Baker have urged that it is the patriotic duty of all students in engineering colleges to stay in school if possible until actually called to the colors. The War Department recognizes that technically trained men are essential to all army operations and intends to detail drafted men who have taken engineering courses to the type of service for which their training best fits them. To this end students who may not be recommended for enlistment in the enlisted reserve corps but who remain in school until called to camp are authorized to file with their occupational census questionnaire at camp, a letter from the president of their school stating their special qualifications. The Secretary of War has assured the colleges that every effort will be made to use each student's special training in the specialized occupations of the army.

8. It will ensure prompter action on the certificates if each school will submit together with the certificates, a table showing the number of students in the freshman, sophomore, junior and senior classes who were pursuing regular engineering courses during each of the last two academic years: and the

number of graduates in engineering in each of the last two academic years; also a description of its marking system.

9. The War Department does not plan to issue any printed blanks for the certificates called for in the regulations—each school must supply its own in the standard form.

Respectfully submitted,
F. L. Bishop, *Chairman,*
C. S. Howe,
M. S. Ketchum,
C. R. Mann,
S. P. Capen,
Committee on Engineering Education
of the Council of National Defense.

EDITORIAL.

ENGINEERING STUDENTS ENTER THE MILITARY SERVICE WHILE IN SCHOOL.

It has been recognized from the very beginning of the war, not only by the Secretary of War but by other officials in Washington, that the successful outcome of the war for the Allies is dependent upon the service of technically trained men.

If the war is to last for a year or perhaps two, then we are all agreed that every student should do his part by dropping his school work temporarily, but if the war, as we believe, is to be of long duration, then it becomes absolutely necessary that technical students should be continued in school to complete their courses in order that a supply of such men may be available during the war and for the reconstruction period which is to follow.

This matter was taken up by Dr. Godfrey as a member of the Advisory Commission of the Council of National Defense early in August and referred to the Committee on Engineering Education of the Council. This committee coöperated with various other agents in bringing the matter directly to the attention of the officials in the War Department most interested in this matter.

Students taking special courses such as that for radio engineers under the direction of the Signal Corp of the U. S. Army are to enlist in the Engineer Enlisted Reserve Corp, and state in their applications that they prefer service with the Signal Corp.

The following letter was received from Dean A. A. Potter, of the Kansas State Agricultural College, and shows the enrollment in Land Grant Institutions.

The S. P. E. E. may be interested in an investigation which I recently made with reference to the effect of the war upon the engineering enrollment of Land Grant Institutions.

A circular letter was sent out to the deans of engineering divisions of land grant institutions. Replies were received from thirty-three institutions with results as indicated below:

1. The enrollment in 1917–1918 as compared with 1916–1917 indicated an average decrease of 20.8 per cent. The losses for separate institutions varied from 4 per cent. to 42 per cent.

2. As compared with 1915–1916, the enrollment in 1917–1918 indicated an average loss of 20.1 per cent. The losses varied from 3.5 per cent. to 38.6 per cent.

3. Gains in enrollment at the beginning of the academic year 1917–1918 as compared with 1916–1917 were given by the Alabama Polytechnic Institute, the University of Florida, the New Hampshire State College, Rutgers College and the Texas A. & M. College.

4. As to geographical location, seven Institutions in the North Atlantic Group reported for 1917–1918 an average decrease of 20 per cent. as compared with 1916–1917. Five Institutions in the South Atlantic States show an average decrease of 12 per cent. The average loss for nine institutions in the North Central States is given as 23.2 per cent. The six institutions in the South Central States indicated an average loss of 18 per cent., while four institutions from the Western States showed an average decrease of 25 per cent.

5. The greatest loss seems to be in architecture, the average being 44 per cent. The average loss in electrical engineering is 28 per cent., in mechanical engineering 25 per cent., in civil engineering 23 per cent., and in chemical engineering 12.5 per cent. Four institutions reported gains in mechanical engineering, four in electrical engineering, eight in civil engineering, and nearly one half of the institutions teaching chemical engineering reported gains.

6. The losses for the various classes were approximately as follows:

	Per Cent.
Freshmen	1.5
Sophomores	14.2
Juniors	32
Seniors	31

BOOK REVIEWS.

Technic of Surveying Instruments and Methods—A manual of exercises in the use of surveying instruments and methods of surveying together with sample student surveys. By WALTER LORING WEBB, C.E., and JOHN C. L. FISH, C.E. First edition. New York, John Wiley & Sons. 319 pages. Cloth, 4 × 7.

The purpose of the author is not to replace any general textbook in surveying but to supplant the general directions in such a book by detailed directions for specific operations in the field and office. It is aimed to make these detailed directions so complete that the student can go through the routine of the exercises without verbal instruction, so that the instructor may be free to watch carefully the performance of each student, and give advice, explanation, suggestion, caution or illustration according to the needs of that student.

Each of the various surveying instruments are taken up in turn and graded exercises given designed to give the student a maximum amount of practice in manipulation and reading in a given time. The exercises are also in the nature of experiments in that the student has forcibly brought to his attention the sources and range of error in the operation performed. Following the exercises on manipulation are a series of exercises on surveying methods in which simple but practical exercises in differential and profile leveling, traverses, stadia work, curves, etc., are given.

In a separate section of the volume, complete descriptions and detailed directions for a complete student railroad survey (including the paper location and the final field location), a complete student topographic-hydrographic survey, and general directions regarding planning surveys are set forth, while the final section is made up of exercises in the use of the various office instruments and processes connected with the measuring of areas, plotting of maps and traverses, making of diagrams, constructing of scales, plotting of contours, etc.

The value of a book of this sort for use in connection with a course in surveying is beyond question; and the value of this particular book is further enhanced by the circumstance that it is the outcome of an extended experience both in the classroom and in actual practice. It is a book with a purpose, and that purpose has been admirably fulfilled.

L. W. McI.

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PERSPECTIVE IN ENGINEERING EDUCATION.

BY CLEMENT C. WILLIAMS,

Professor of Railway Engineering, University of Kansas, Chairman of Committee on Economics, Society for Promotion of Engineering Education.

Is it not a fact that technical education has not been as effective as it might have been, due to the limited perspective in teaching and in studying? The writer is inclined to believe that his own teaching has suffered from this cause and from observation concludes that such is the case more or less generally. The student is not taught to look beyond the immediate conditions of the problem confronting him to the background of associated circumstances and ultimate relationships. This fragmentary and partial mode of thought thus formed by the student in the classroom problems and discussions influences his procedure and practices in his professional life later. Two instances within the writer's recent observation illustrate the idea in mind.

One draftsman in designing a turntable to carry Mikado locomotives used Cooper's E–60 wheel loadings. Cooper's wheel loadings apparently represented to him a stock set of conditions for the calculation of stresses, to be used always when stresses were to be computed for locomotive loads, and he proceeded accordingly without taking into consideration the fact that the greater wheel spacing of a Mikado type of locomotive would cause greater moment on a cantilever turntable than would the concentrated or closely spaced loadings of Cooper's series, which, of course, were arranged to give maximum moment in simple spans. He had not looked beyond the immediate problem of calculating stresses and proportioning parts. In the other case, a draftsman designed a reinforced concrete icehouse that was the acme of perfection as a reinforced concrete structure, but owing to the neglect of any consideration of the thermal conductivity of the walls, it would have served its purpose as a preserver of ice but poorly.

The faults in both of these cases were similar in character, namely, the viewpoint was only immediate, while the ultimate and complete relationships had been ignored. It is the writer's opinion that the effect of such faulty processes may be traced in the larger features of engineering practice, particularly with reference to the economic phases of engineering.

The old definition of Tredgold's given in 1828 and frequently quoted, that "Engineering is the art of diverting the forces of nature for the use and convenience of man," has doubtless done the profession much harm, or, at least, the conception thus expressed has done it harm, because of its incompleteness and inadequacy. It served, perhaps, for the beginnings of engineering but it should scarcely be used to define the limits or to set the boundaries of engineering at the present time. The definition would more nearly fit the modern profession if it read: "Engineering is the *science, art* and *business* of diverting *economically* the forces and materials of nature for the use and convenience of man," for engineering is all of these.

Engineering is a science because it requires an intimate knowledge of scientific laws and principles for its successful practice. It takes the high potential concepts of pure science and steps them down through its transformers of plans and specifications so that the lay constructor, contractor or carpenter can understand and apply the same. It is an art, for it has to do with achievement. There is a vast deal of difference between knowing *how to do a thing* and knowing *how to get the thing done.* Engineering recognizes this fact and couples to the knowledge of science the art of achievement. Engineering is also a business, for it has a commercial aspect; it aids its practitioner in making a living and it is directly concerned with producing, exchanging and distributing the world's wealth. Moreover, unless a given engineering work is connected up and correlated in the scope of the plans to these phases of economic organization, there is still something lacking in its design. This last sentence perhaps should be amplified somewhat.

Engineering economics has been too narrowly conceived. To select a structure or machine so that the total annual charge or cost consisting of fixed charges, maintenance, depreciation, and operating expenses shall be a minimum is certainly not the sum total of engineering economics. This simple mathematical relationship is neither complete nor adequate. Minimum annual cost is not more important, perhaps it is less important, than maximum annual net earnings. Engineering has been held in rather low esteem, a sort of necessary evil, by capitalists and managers, because it has concerned itself so completely and has been so inextricably associated with the *spending* of money rather than with the *earning* of money. More emphasis should be placed on the value and benefits derived from engineering operations and less on the details of spending the money, although the careful study of this latter phase should be by no means neglected. Engineering economics, therefore, should take into consideration the ultimate purpose of the structure, machine or project. Irrigation projects have failed in many instances, notwithstanding the fact that dam, canal, headworks and all other parts were selected on sound scientific and "economic" principles, because the ultimate phase of the problem, namely the settling of the population on the land, the tillage of the soil and the marketing of the crops, was not considered. Many hydro-electric plants have been failures to a greater or lesser extent not because the plant and machinery were not well designed but on account of a lack of market for the power developed. Railroads have gone into the receiver's hands in many instances not because the grades and alignment were poorly selected, but because there was no traffic or else the location was not properly designed to serve well the traffic that was secured. In these cases, and others might be mentioned, the ultimate relationships were not duly considered. Another definition of an engineer that contains a grain of truth, and a pound of untruth because of its incompleteness, should be mentioned in this connection. It is: ''An engineer is a man who can do with one dollar what a fool could do with two.'' The fact is that an engineer may be the man who can do well and adequately with two dollars what a fool will try to do with one. If the additional expenditure would make the project in character and scope commensurate with the technical and economic needs of the situation while the smaller amount would not, the niggardly expenditure certainly would not be in accordance with good engineering.

The sum of the matter is that the perspective or point of view of engineering operations should be from the consideration of the ultimate and complete function of the project and its relation to the complicated social and economic organization rather than from its immediate and limited connection as a technical problem, and that students should be taught to seek the complete and final analysis of a problem rather than the immediate, and perhaps partial or fragmentary, application of its principle.

THE EFFECT OF THE WAR ON ENGINEERING EDUCATION.*

BY C. R. MANN,

Carnegie Foundation for the Advancement of Teaching.

Three years ago most of us thought that a world war could not last long because, however much kings and kaisers might wish to continue, the banker would stop it. But the financiers have not come up to our expectations in this matter, and we have therefore been compelled, unwillingly perhaps, to recognize that money is not the ultimate measure of national strength. National credit is the result and not the cause of intelligent industrial production; the engineer, not the banker, is the real power behind the throne.

This fundamental fact now seems so simple and self-evident that it is rather hard to remember the time when we thought otherwise. But though the rugged outlines of this fact are now sharply silhouetted against the ruddy dawn of the new age, the details of its meaning are but dimly discernible through the haze of speculation over the significance of the struggle. Naturally the engineer is intensely interested in the development of the details of the picture, for on him devolves the duty of interpreting the coming conceptions in terms of materials and organizations of men. And if education makes men, engineering education must be the first to feel the thrill of the dawning day.

Three elements in the picture can now be plainly perceived. These indicate that the engineer is from henceforth vitally involved in the control of credit, in the interpretation of the daily news, and in the organization of industry and commerce to make goods cheap and men dear.

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* This article was written at the request of the Editor, but appeared in Vol. 80, No. 5, p. 208, *Engineering-News Record.* This is second of a series of articles on the effects of the war on engineering education, being published in this magazine.

In performing the first of these new functions, the engineer becomes the partner of the banker to determine which projects are worthy of financial support and which not. As the engineering spirit is more and more infused into this dispensing of credit, public service rather than excess profit becomes the inspiration for enterprise; intelligence in production becomes the best security for loans; ability to deliver the goods becomes the sure basis of financial success; and the control of tools gradually passes from the hands of those who own them legally into the hands of those who can use them effectively.

Newspapers and periodicals already sense the expansion of the engineering spirit in the struggle to make the nation strong. The distribution of wheat, the supply of sugar, the transportation of coal and the price of bread are now subjects which occupy an amount of space in the daily press that only a murder trial could formerly command. The public has never before realized how vital and how interesting factories, freight cars, warehouses, terminals, trucks, and ships really are. Some faint conception of the necessity of organization for the common project of liberating life by winning the war seems to be taking shape; while an impelling desire to serve and to subordinate personal preferences to community interests appears to be dimly developing. These faint feelings of fraternity may grow into driving impulses, if editors continue to extol engineering enterprise rather than private profit in their interpretations of the daily news.

In many communities chambers of commerce or groups of engineers have organized to build up business and boom the town. Through their efforts living conditions have been improved and many a city is being made a better place for homes. But the progress has always been hampered by the vested rights of individuals and of corporations, so that none has yet dared to envisage an entire community as a single working plant for the purpose of organizing it for the most intelligent production of human wealth. This can now be done. The war is opening many hitherto blind eyes to see that each gains more than he loses when he merges his strength with the might of all in an organization that is constructed for the purpose of releasing creative energy by giving each the work he is best qualified to do.

The time has come for such an organization in every community and every state, because the federal government is struggling to shape the nation into an organization of this type. Only so may the nation be strong; only so may communities add their utmost to the nation's strength. The responsibility for this work must finally be shouldered by engineers who are both masters of the mechanic arts and moulders of men.

For many years this country has been drifting toward the realization of these requirements. The war has but accelerated the process and precipitated conclusions that were bound to come, otherwise men trained by experience to meet the present crisis could not now be found. Continuity demands that the same conclusions remain valid long after the war is ended. Therefore engineering schools will render service in proportion as they grasp the implications of these conclusions and express them effectively in the daily work of instruction.

The possible conclusions for engineering education are many and complex, but two stand out in bold relief, namely, there must be closer coöperation between school and industry, and there must be more attention to the appraisement of values and costs.

The essential feature of the coöperation with industry is not the skill, the knowledge of workmen, or the feel of the machines which the student acquires from shop experience. Important as these are, they cannot compete with the spirit of investigation which must develop if the coöperation between school and industry is real and vital. There are thousands of unsolved problems in even such rough shop work as freshmen are permitted to do. The boy should be trained to discover these unsolved problems and to bring them back to school for discussion and solution. By making shop work in industrial plants the source of problems for solution in school, and by relating the class and the laboratory work in some degree to the problems raised, conditions most favorable to the self-development of the student may be realized. As he progresses, the problems become more and more intricate, until in his last year, if he has shown real engineering ability, he may be assigned as helper in industrial research, either at the plant, or in the school laboratories. After such a training in defining and solving problems, closely coördinated with instruction in science and drill in mathematics, he should be able on graduation to take a responsible position without serving several years as an apprentice, as is usual under present conditions.

To the faculty this type of coöperation with industry brings incentives for creative work in production and in education. For coöperation makes the school the source of solutions of industrial problems, not only with respect to the technique of manufacture, but also concerning the correlation of the community's productive processes with the training of its citizens as intelligent workers. Hitherto manufacturing companies have stood aloof and regarded one another with suspicion—and the Federal Trade Commission discovered that 200,000 of them are not paying expenses; but now they are ready to coöperate. Similarly in education, many manufacturers are supporting corporation schools to train their own help, while more than half the children in the entire country quit school at the sixth grade without being trained to earn a living: but they too are now ready to coöperate. If the men who are teaching in engineering schools rise to the responsibility and organize for the systematic study of community production, they could soon create a true university, with its feet firmly planted in industry and its soul consecrated to the task of utilizing science and literature to liberate the creative energies of men.

While close coöperation between school and industry gives that practical experience which is essential for mastery of the mechanic arts, it is not in itself sufficient to enable the schools to meet adequately the fundamental requirements of engineering in the new epoch. The Germans are technically well trained in the mechanic arts, yet they are but brutally strong. In order to strengthen the nation by infusing the engineering spirit in the control of credit, in the interpretation of the daily news and in the organization of industry for the production of human wealth, the engineer must have sound judgment in the appraisement of values and costs. This requires not only an understanding of finance and the meaning of money, but also a sympathetic appreciation of the things humanity holds to be most worth while. Even a practical project like building a bridge is ultimately controlled by some man's decision that the resulting value is worth the cost; and this decision is more difficult and subtle when it concerns profoundly the production of human wealth and the appraisement of human values and costs. The engineer is too often obliged to be only the employee of the bank, the corporation, or the state commission, because he believed that engineering is wholly a matter of technical skill; when control in this, as in everything else, is really vested in the decision of the question whether the game is worth the candle.

Training in the appraisement of values and costs does not require the addition of formal courses for that purpose, but rather the injection of this point of view into every branch of school work. For example, experiments in chemistry need not always be of the type: Analyze this baking powder. The project: Make baking powder and find out if it is cheaper and better than any you can buy, is vastly more effective as a training exercise. Presented as a personal effort to appraise the human values and costs in life's experiences, literature fascinates engineering students. Economics delights them when it is a critique of proposed solutions of the social problems defined by their daily coöperation with labor. Such exercises also foster the development of those homely virtues, which always make the working people the bulwark of a nation's strength—the sense of justice, feelings of neighborly kindliness, devotion to right, and respect for God and man.

Thus because the war has revealed a profounder appraisement of human values and costs, and because the war has hastened the transformation of the individualistic man, selfishly seeking his own personal profit, into a community man willing to do his best for the common welfare, the ideal that was set for the engineering schools in the passage of the Merrill Act in 1862 may now be achieved. For many of the first schools founded under that act were called ''industrial universities''; but they soon dropped the ''industrial'' from their titles, fearing lest they lose caste in academic councils. But now, if they gladly grasp the opportunity opening before them, they will claim with pride their abandoned surname and proceed to demonstrate that the engineer, the creator of a new earth, is also the prophet of a profounder philosophy of life.

OUTLINE OF COURSE IN DIRECT-CURRENT MACHINERY.

BY H. C. BARTHOLOMEW,

Associate Professor of Electrical Engineering, Iowa State College.

From the standpoint of methods of teaching, engineering courses may be classified under two heads:

(*a*) Those subjects in which nearly all the material presented is illustrated by the solution of numerical problems.

(*b*) Those subjects in which fifty per cent. or more of the class-room work calls for explanations of fundamental principles and for discussions involving the application of a knowledge of these principles.

Courses of the second class are sometimes difficult to present in such a way that the average student will have a clear idea of the exact nature of the problems he will be called on to solve, since the text may be confined mainly to explanation of fundamental principles and may not state all the problems involving the application of these principles that the instructor would like to present. It is usually unfair to the student to expect that, having learned the fundamental principles, he should be able, in the limited time afforded for examinations, to apply them to the solution of a problem new to him, or even to a problem which has been briefly discussed in class, but is not stated in the textbook.

An outline given to the student in printed or mimeograph form, which states all the questions he will be called on to answer and in general terms all the numerical problems he will be called on to solve, should help him to find out what the course is designed to teach; it should also give the instructor greater latitude in examinations, since the student may reasonably be expected to discuss any topic in the outline.

COURSE IN DIRECT-CURRENT MACHINERY.

The accompanying outline is given in mimeograph form to the electrical engineering students at the Iowa State College taking the course in direct-current machinery. It is arranged for a four-hour course to be taught by the recitation method to students who do not study the design of electrical machinery. So far as possible, questions have been so stated as to require an answer based on the physical rather than on the mathematical viewpoint and stress has been laid on the idea that the function of the course is to teach the student to answer the question "why" and not the question "what." An effort has been made to so word the questions as to require an actual analysis and to eliminate camouflage answers.

While there is room for opinion as to what should constitute a course in Direct-Curent Machinery, the writer believes that this subject can be more efficiently taught with the aid of an outline similar to the one here presented, arranged to suit the conditions under which the course is given.

OUTLINE OF COURSE IN DIRECT-CURRENT MACHINERY.

The following is an outline of the course in direct-current machinery. Topics in it, together with parts of the text, will be assigned for recitation and for written examinations during the semester. A final examination will cover the entire outline together with the solution of numerical problems. The outline is general in character and is not made out with reference to any particular text, so that it may not follow the order of the text which is used.

Introductory.

1. Elementary explanation of different types (shunt, series and compound) motors and generators.

2. Details of construction of armature, commutator, brush rigging and frame. Only a small amount of time will be given to this topic.

3. Mechanical features and magnetic characteristics of cast iron, cast steel and rolled steel frames, and of cast steel and laminated poles.

4. Paths of useful and of leakage magnetic fluxes and definition of coefficient of magnetic leakage. Reasons why poles cover only about three quarters of the armature surface. (No problems on the magnetic circuit of the dynamo will be given.)

5. Theory of the bipolar and multipolar ring winding (arrangement of winding, position of brushes, connection of brushes, path of current through windings, resistance of armature). This type of winding is obsolete, but is the electrical equivalent of modern windings and is universally used for purposes of explanation on account of its simplicity.

6. The fundamental equation of the dynamo (derivation and application to the solution of numerical problems).

Armature Windings.

7. Theory of simplex and duplex, lap and wave windings, including determination of proper winding and commutator pitches for a given case, determination of reëntrancy of winding, determination of winding to fit case of a given machine generating a given voltage, and use of dummy coils.

8. Solution of problems calling for representation in developed form of armature windings of above types.

9. Paths in parallel, resistances, and voltages generated by above types of windings.

10. Reasons equalizers are necessary in lap windings and are not necessary in wave windings.

11. Reasons why equalizers prevent sparking.

12. Reasons why lap-wound machine with unequal air gaps when putting out its rated current will have greater armature I^2R losses than when putting out its rated current with equal air gaps.

Special Forms of D.-C. Machines.

13. Dynamotor—used for same purpose as motor-generator set.

14. Homopolar generator—has no commutator.

15. Train-lighting generators—designed for variable speed.

16. Automobile generators—designed for variable speed.

Only a small amount of time can be given to these special forms of machines.

Three-Wire Generator.

17. To be covered in course in alternating-current machinery.

Armature Reaction.

18. Theory of the effect of the magnetomotive force of the armature conductors lying under the poles on the distribution of the flux in the air gap.

19. Theory of the effect described in (18) on the total flux per pole and on the generated E.M.F., for a machine operating at no load at a point just above the knee of the magnetization curve. To be discussed for case of light load and for case of heavy load.

20. Theory of the effect described in 18 on the position of the brushes.

21. Theory of the effect of the magnetomotive force of the armature conductors lying within the double angle of brush lead on the main flux and generated E.M.F.

22. Problems involving the computation of armature cross-magnetizing ampere turns, armature demagnetizing ampere turns, and series field turns to compensate for armature demagnetizing ampere turns. The problem of computing the series field turns to compensate for the demagnetizing effect due to the cross-magnetizing action of the armature will not be called for.

23. Discussion of the various schemes of reducing, or of compensating for, the cross-magnetizing effect of the armature.

24. Discussion of the schemes for eliminating, reducing or compensating for, the demagnetizing effect of the armature due to the turns within the double angle of lead (may be eliminated by use of commutating poles; reduced by application of schemes in 23 which reduce brush lead; compensated for, by use of series field winding).

25. Theory of the dependence of the length of the air gap on armature reaction, to include:

(*a*) Discussion of the necessity of providing at the commutating pole tip a main field of greater flux density than that of the field due to the armature cross-magnetizing action.

(*b*) Discussion of the ratio between the field ampere turns per pole used for gap and teeth to the armature cross-magnetizing ampere turns for gap and teeth.

(*c*) Problems calling for determination of the length of the air gap for a given machine to meet the ratio mentioned in (*b*).

The Shunt Generator.

26. Proof that the no-load voltage is at the intersecion of the magnetization curve and the field-resistance line.

27. Conditions under which machine will and will not build up—to include effect of increase in field resistance, high mica, reversal of field connections, reversal of direction of rotation, reversal of direction of residual magnetism, and of operating at speeds below normal.

28. Methods of reversing polarity.

29. Explanation of all reasons for change in terminal voltage with load—to include discussion of effect of armature resistance, armature reaction, change in shunt field excitation, current in short-circuited coil undergoing commutation, and brush contact drop.

30. Explanation of shape of characteristic curve—this must include reasons why the curve drops more and more rapidly as the load is in-

creased, which necessitates an explanation of the variation of voltage drop with load due to each of the factors mentioned in 29.

31. Explanation of effect on characteristic curve of operating a self-excited machine at speeds below normal, but with no-load voltage kept at normal value by change in field rheostat resistance. To be illustrated by a problem.

32. Problem of determination of characteristic curve for self-excited machine from magnetization curve and other data.

33. Problem of determination of volt-speed curve for self-excited machine from magnetization curve and other data, and of determination of critical speed. To be illustrated by a problem.

34. Application—*i. e.*, types of load to which the machine is adapted.

The Series Generator.

35. Practically the same topics as for the shunt generator. The series generator is but little used and not much time will be given to it. No numerical problems to be given.

Special Forms of Series Generators.

36. Thompson-Houston arc-lighting generator. Brush arc-lighting generator.

Will only be mentioned. They are of historical and theoretical interest only.

Compound Generator.

37. Explanation of shape of characteristic curve—this must include reasons why the curve is not a straight line, which necessitates an explanation of reasons why the series field can not be made to compensate exactly at all loads for the drop due to all of the factors mentioned in 29 and of effect of this lack of perfect compensation on the shape of the curve.

38. Adjustment of degree of compounding.

39. Influence on characteristic curve of changing connections from short to long shunt (while it is, in general, not possible to state definitely whether the full-load voltage will be increased or decreased by the change, the factors which tend to change the voltage can be explained).

40. The armature characteristic curve and its use in designing the series field winding.

41. Application—*i. e.*, type of load to which the machine is adapted.

Motors—General.

42. Reasons why motor must develop a counter E.M.F. and the relation between counter E.M.F., line E.M.F. and drop in the armature.

43. Siemens's Law of Efficiency and reasons why the counter E.M.F. should be nearly equal to the line E.M.F.

44. Fundamental formula for speed. Derivation and application to the solution of numerical problems.

45. Fundamental formula for torque and reasons for difference between torque developed within the armature and that developed at the pulley.

46. Reasons why the motor current depends in only an indirect way on the resistance of the armature, but depends primarily on the load. It should be clearly understood that the armature current is *not* equal to the line E.M.F. divided by the armature resistance; one way to illustrate this is to consider the case of a motor, whose speed is controlled by a rheostat in the armature, driving a load demanding constant torque at all speeds, say a plunger pump working against a constant head—what will be the effect on the armature current in this case of varying the resistance in the armature circuit.

47. Influence of armature reactions on brush position and total flux entering the armature (this is in review).

The Shunt Motor.

48. Reasons for shape of speed-current curve. This explanation can be based on the formula derived in 44. It must include the effect of brush contact drop and armature RI drop on the numerator of the formula and the effect of shape of magnetization curve, armature reaction, and current in the short-circuited coil undergoing commutation, on the denominator and statement as to the resultant effect of all these factors on the curve.

49. Reasons for shape of torque-current curve. Involves discussion of same factors as in 48.

50. Figures for values of speed regulation in large and small motors.

51. Effect on speed at no load and under load of changes in field, armature and line resistance.

52. Proof that neglecting all factors excepting armature resistance and neglecting drop in armature at no load, the speed regulation is independent of the adjustment of the shunt field rheostat—to be proven by substituting formulas for speed at no load and under load (derived in 44) into formula for speed regulation and simplifying the resulting expression.

53. Effect on current and heating, of operating with line voltage below normal.

Adjustable-speed Shunt Motor with Field Rheostat Control.

54. Approximate change in each of the losses and in heating of commutator, fields and armature with speed. To be illustrated by a numerical problem.

55. Reasons why this type is heavier and more expensive than a constant-speed shunt motor of same horse-power rating, designed to operate at the highest speed of the adjustable-speed motor. This may be explained in various ways. One illustration is the following: consider the case of a four-pole, wave-wound, adjustable-speed motor with a two-to-one speed range.

The motor can develop no more horse power at its highest speed than at its lowest speed (why?). Suppose, however, the motor is re-designed for constant-speed operation at its highest speed by changing its armature winding and using the same field current that was originally used at its lowest speed. What change would be made in the winding and, neglecting the extra heating due to the increased stray power losses, how many times the original rated horse power could the motor develop.

Methods of Speed Control.

56. The methods to be considered are:

(*a*) Field rheostat method.
(*b*) Armature rheostat method.
(*c*) Adjustable air-gap method.
(*d*) Multi-voltage method.
(*e*) Ward-Leonard method.

57. Explain reasons for following advantages of (*a*) over (*b*):

(1) Higher efficiency.
(2) Better speed regulation.
(3) No reduction in horse-power capacity at low speeds.

Note.—In an examination, this might be stated: state all advantages of (*a*) over (*b*) and explain reasons for each of the advantages. This note applies to all similar questions in this outline.

58. Explain reasons for following advantages of (*b*) over (*a*) and (*c*):

(1) Greater speed range.
(2) Less total cost for motor and rheostat.

59. Explain reasons for greater speed range of (*c*) than (*a*)—for non-commutating-pole motors.

60. Explain arrangement of (*d*) and its advantage over (*a*).

61. Explain arrangement of (*e*) and its advantage over (*a*).

62. Approximate motor current and efficiency with fan load (torque varies as square of speed) driven by motor with armature rheostat con-

trol, at half-rated speed. Current to be expressed in terms of current at rated speed. Also approximate rheostat loss at half speed in terms of motor input at full speed. This last answer will show one of the reasons why this method of control is sometimes used for driving fans.

63. Same as 62 except for a constant torque load, say a plunger pump working at variable speed against a constant head. Note difference in rheostat loss in the two cases.

Series Motors.

64. Reasons for shape of speed-current curve. See 48 for factors to be considered.

65. Reasons for shape of torque-current curve. See 49 for factors to be considered.

Series-Parallel Control.

66. Connections of motors and rheostat on the various resistance, running and transition notches.

67. Advantages of series-parallel control.

68. Changes in torque of motors during transition from series to parallel.

Cumulative-Compound Motors.

69. Same questions as for series motors.

Differential-Compound Motors.

70. Same questions as for series motors.

71. Effect of operating a motor with a rising speed characteristic curve on a load whose torque increases with speed.

Application of Motors.

The student should be able to apply the correct type of motor to a service with the requirements of which he is familiar and should be able to give the reasons for using the type of motor selected. A few typical examples will be studied and the text will be supplemented by references in the handbooks to some of these examples.

72. Reasons for superiority of the series motor over other types for operating crane hoists, electric shovels and for railway service.

73. Reasons for superiority of compound motors over shunt or series motors for loads which require fly-wheels (for example, a punch) and the effect on the load curve of using the compound motor and fly-wheel, instead of a shunt motor.

74. Reasons why a compound motor when operated with a weak shunt field has very poor speed regulation, so that compound motors are not adapted, for constant-speed applications, to a wide range of speed con-

trol by means of a field rheostat. To be illustrated by a numerical problem.

75. Reasons for advantage, for heavy elevator service, of a compound motor with arrangement to short-circuit the series field when up to speed, over a plain shunt or a plain compound motor of the same horse-power rating. Starting torque and speed regulation are the factors to be considered. Make a comparison of the three motors when designed for the same speeds at no load, and also a comparison assuming they are all designed for the same speed when raising the elevator while carrying its rated load.

76. Reasons for advantage, for high-speed elevator service, of a 2:1 adjustable speed shunt motor with field rheostat control, over a compound motor with arrangement to short-circuit the series field when up to speed. The factors to be considered are those mentioned in 75 and, in addition, simplicity of control and dynamic braking. The last is of great importance in high-speed work where a mechanical brake is not so satisfactory as dynamic braking. Make a comparison of the two motors when designed for the same horse-power rating, the same torque when starting the elevator with normal starting current and the same speed when raising the elevator while carrying its rated load.

77. Reasons for advantage of a constant-speed shunt motor with armature rheostat control over an adjustable-speed shunt motor with field rheostat control for driving a fan requiring adjustable speed, but running most of the time at its highest speed. The speed range of the fan is to come within the speed range of the adjustable-speed shunt motor (*i. e.*, the advantage of the armature rheostat control scheme in this case is not its greater speed range). See (55), (62) and (63) for factors to be considered.

78. Reasons for advantage of adjustable-speed shunt motor with field rheostat control over a constant-speed shunt motor with armature rheostat control for driving a fan requiring adjustable speed, but running most of the time at its lower speeds. See 77 for factors to be considered.

79. Reasons for advantage of compound motor over shunt motor for operating planers with mechanical reversing arrangement.

80. Reasons for advantage of shunt motor over compound motor for operating lathes and drill presses. Factors to be considered are speed regulation and the factor discussed in 74.

81. Reasons for advantage of Ward-Leonard system over other systems of control for operating large motors used for reversing service, as in reversing service in steel mills. Factors to be considered are (*a*) simplicity and low cost of controller, (*b*) efficiency (*i. e.*, combined efficiency of motor and control rheostats) and (*c*) use of fly-wheel.

Starting Boxes.

82. Connections of three and four terminal types of boxes.

83. Connections and operation of overload and of no-voltage release coils.

84. Connections of starting and regulating box.

85. Connections of:

(*a*) Arcing tip to take initial and final arc.
(*b*) Laminated copper brush to short-circuit the sliding contact on last notch.
(*c*) Arrangement to cut starting resistance out of field circuit on last notch.
(*d*) Arrangement on starting and regulating box to short-circuit field rheostat while starting.

86. Essential difference between three and four terminal types.

87. Reason that four terminal type is usually used for adjustable-speed motors using field rheostat control.

Note.—Only a small amount of time will be given to this topic and it may be practically omitted. This subject can well be learned in the laboratory.

Automatic Starters.

88. This subject is not to be covered.

Commutation.

89. Statement of condition (complete reversal of current during time of commutation) for perfect commutation.

90. (*a*) Complete explanation of reasons why sparkless commutation will result if condition in 89 is met. Explanation is to include a representation of a portion of a ring-wound armature at one of the brushes, showing conditions when the coil undergoing commutation is just at the end of the period of commutation. On the sketch are to be shown direction of rotation and direction and relative magnitude of all currents:

(1) In coil undergoing commutation.
(2) In coils adjacent to coil undergoing commutation.
(3) In commutator risers of coils mentioned in (1) and (2).
(4) In lead attached to brush.
(5) Arcing between edge of brush and commutator segment just leaving brush.

(*b*) Complete explanation with diagram similar to that in (*a*) of reasons why sparking will result if condition in (89) is not met.

91. Explanation of effect of inductance of coil undergoing commutation in tending to prevent condition stated in 89.

92. (*a*) Statement of condition to be met for neutralizing the effect of the E.M.F. of self-induction of coil undergoing commutation (equality of E.M.F. of self-induction and E.M.F. of rotation of coil undergoing commutation).

(*b*) Mathematical expression for E.M.F. of self-induction of coil undergoing commutation, under conditions of perfect commutation, in terms of coefficient of self-induction, current per coil and time of commutation.

93. Explanation of direction of brush shift from magnetic (as distinguished from geometric) neutral to obtain the E.M.F. of rotation mentioned in 92. To be explained for both motor and generator.

94. Explanation of way in which brush contact resistance will accomplish reversal of current mentioned in 89 if condition mentioned in 92 (*a*) is effected. To be explained by means of diagrams similar to that mentioned in 90, showing conditions at beginning of commutation and when commutation is one fourth, one half, three fourths, and fully, complete.

95. Reasons why a shunt generator running at no load will spark if the brushes are shifted either way from the geometric neutral.

96. Explanation of the following, for each case to be based on:

(*a*) Change in E.M.F. of self-induction, determined from formula called for in 92.

(*b*) Change in strength of commutating field (can be stated only approximately in some cases).

(*c*) Change in speed at which coil undergoing commutation cuts the commutating field.

(*d*) Change in E.M.F. of rotation of coil undergoing commutation (determined from (*b*) and (*c*)).

(*e*) Change in relation between E.M.F. of self-induction and E.M.F. of rotation of coil undergoing commutation (*i. e.*, the final explanation is to be based on the criterion for perfect commutation stated in 92).

Case I. Commutation at full load of a shunt generator which has perfect commutation at half load.

Case II. Commutation at 1,200 R.P.M. of a 600–1,200 R.P.M. adjustable-speed shunt motor using field rheostat control, which commutates perfectly at 600 R.P.M.

Case III. Superior commutating quality of series motors under varying loads, over shunt motors under varying loads.

COMMUTATING-POLE MACHINERY.

97. Explain polarity of commutating poles for case of motor and for case of generator.

98. Armature reaction in commutating-pole machinery.

(*a*) Reasons why the effect in 21 is eliminated.

(*b*) Reasons why the effect in 18, for the air gap under the main poles, is practically not affected by the introduction of commutating poles.

99. Commutating-pole magnetic circuit and magnetomotive force of commutating-pole winding necessary for this circuit.

100. Variation in flux in commutating-pole air gap with load.

101. Reasons for use of neutralizing winding.

102. Effect on voltage of generator and on speed of motor of operating with brushes shifted ahead of, and back of, the commutating-pole neutral.

103. Reasons for use of compensating windings in the pole face, in commutating-pole machines.

104. Reasons for the very poor speed regulation of a commutating-pole motor run with the commutating-pole winding cut out, but with the commutating poles left in position, and brushes left on the commutating-pole neutral.

105. Explanation of the following, for each case to be based on the same factors as those mentioned in 96:

Case I. Reasons why commutation of a shunt generator will be practically perfect at all loads, if perfect at any one load.

Case II. Reasons why commutation of an adjustable-speed shunt motor, using field rheostat control, will be practically perfect at all speeds, if perfect at any one speed.

Flash Over.

106. Discussion of influence in starting flash over on sudden overload of:

(*a*) Voltage induced by shifting of cross flux.
(*b*) Vapor set up by arcing at brushes.

107. Reasons for difference in ability to withstand flash over of same machine when operated:

(*a*) As a motor.
(*b*) As a generator.

Parallel Operation.

108. Connections for commutating-pole and for non-commutating-pole generators.

109. Reasons for instability of overcompound generators in parallel without equalizers.

110. Reasons for stability of overcompound generators in parallel without equalizers, when in different stations with resistance in the line, as in railway work.

111. Reasons for stability of undercompound generators in parallel without equalizers.

112. Statement of conditions to be met for perfect division of load between machines of different capacities and explanation of reasons.

113. Explanation of reasons why it may be impossible to effect the proper load division by adjustment of series shunts.

Efficiency and Losses.

114. Formula for hysteresis loss and for eddy current loss of a given dynamo, in terms of speed and flux density.

115. Explanation of variation of hysteresis, eddy current, bearing friction, brush friction, windage, field copper, armature copper and brush contact losses, with load, in:

(*a*) Shunt motor.
(*b*) Series motor.
(*c*) Flat compound generator.
(*d*) Overcompound generator.

116. Explanation of variation of losses mentioned in 115 with speed, in adjustable-speed shunt motor using field rheostat control. To be illustrated by a numerical problem.

117. Explanation of eddy current losses in pole face.

118. Definition of stray power loss.

119. Definition and Explanation of stray load losses. See A. I. E. E. Standardization rules, Sections 219 and 220.

120. Principle which fixes load at which maximum efficiency occurs. Derivation and application to the solution of numerical problems.

121. Approximate efficiency of machines of various sizes.

122. Approximate load at which maximum efficiency occurs in commercial machines.

123. Experimental method of determining stray power loss which a dynamo will have under various loads. This topic will be covered by an experiment in the laboratory course and will not be studied in the classroom.

Dynamic Braking of Series Motor used for Hoisting Service.

124. To be illustrated by a numerical problem.

UTILIZING ENGINEERING STUDENTS—A NEED AND A PLAN.*

Hardly had the engineering schools and the profession adjusted themselves mentally to the rulings promulgated by General Black, whereby engineering students might complete their training, before the Signal Corps proposed a different plan which it hopes will produce 500 graduates of the class of 1918 who will be adept in the theory and practice of radio-engineering. Another method this, differing in particulars, but with results much the same—a second enlisted reserve to be composed of physically fit students above eighteen years of age who will devote the full time of the second term of their senior year to the study of those topics which will fit them to a special purpose, that of military communication.

This proposal has not yet been passed upon by the Secretary of War, but before the echoes of its announcement have died away, rumor has it that the Ordnance Department is to come forward with a third plan, couched in very similar terms and intended to reserve a few hundred mechanical and chemical engineers for specialized training. Nor is even this the end. At the recent meeting of the American Physical Society resolutions were passed petitioning that additional regulations be made permitting certain students in pure science in the universities to complete their studies to the end that they may more thoroughly function in such technical research as will prove of most benefit to war industries or to the military arm of the country.

This situation cries for a centralization of intelligence and authority. However unfortunate it may be, the moment finds Washington with no committee or board properly constituted to undertake the work of examining either the needs of the various and partially conflicting branches of the service, or the most efficient and practicable methods of serving them. True, the Federal Board for Vocational Training has offered its appropriation and organization to this end and has, in a measure, rendered a certain aid to the Signal Corps. But the board recognizes and admits that in matters of higher education it can serve only as an administrative organ, and attempts to handle the question by merely bringing the representatives of the engineering schools to Washington so that they may discuss with army officers, in a huge debating society, the details of an adequate curriculum. Certainly it does not seem reasonable that a board, limited by law to the study and furtherance of secondary education and effectively organized solely to that end, could also be the proper agency to undertake the mobilization of the universities and colleges of engineering—even though war does justify many expedients.

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Soon Secretary Baker must come to a decision which will result in order. The possibility of third-rate medical schools flourishing as refuges for draft dodgers is atrocious. Nor is there anything of particular appeal to loyal engineers in the thought that the technical schools, cross-raked by the needs of different services, may be given the opportunity to degenerate into nests for similar intriguers. A complete coördination of the existing conflicts of interest must be effected immediately.

The *Engineering News-Record* believes that a new agency should be created for this purpose. The need is so paramount that the superficial complications of one more board or committee is of no consequence if some semblance to the rational may result. What is needed is a small body of authorities, with investigational and advisory power, through which the resources of all institutions maintained for higher scientific education may be adjusted to military needs. This body of men would find it a simple matter, and one consuming but little time, to reduce the fast-growing complexity to an ordered plan.

Lest there be the usual accusation that it is easier to propose a general scheme than to reduce it to practice, the *Engineering News-Record* advances the following program:

Let the Secretary of War appoint a board composed of an officer of the general staff; one man thoroughly representative of the medical, dental and veterinary schools; a man who can speak with knowledge of the situation existing in colleges teaching pure science; an authority in higher industrial education; and someone who is competent to speak for the engineering schools. Such a board could make a study of the necessities of the army for young men trained in science or its application, and from it would issue the advice as to how the demand could be filled with the greatest despatch and with the least interference with the progress of other war preparations. They could devise the needed courses of instruction, could rule on the fitness of this or that school to supply the needed training, and, counting on the undoubted loyalty of these institutions, could suggest means through which existing educational facilities might best be utilized to the advantage of all concerned.

It should not be difficult to find men thoroughly equipped for this work. But immediate action is called for, and if reason is to rule, some method such as is suggested above will soon be adopted.

EDITORIAL.

1918 Meeting.—It is almost the instinctive feeling of everyone that the number of meetings of societies should be reduced to a minimum during the war, but this is at once modified by the value which such a meeting may be to the war and the re-construction period which is to follow. The 1917 meeting held in Washington provided a clearing house for discussion of the questions arising in connection with the war and engineering schools at the very beginning of the war. Many of us at this meeting received information which led us to modify greatly our point of view in regard to the relation of engineering schools to the government. Since that time this Society has done a number of things to promote the closer relation of enginering schools to the national government.

It seems to the Editor that the 1918 meeting should be held and that it should be devoted largely to the discussion of the new problems which have arisen in engineering education as the result of our participation in the war. Many of these questions must be solved immediately; many are developing and will be solved only in the years following peace. It may be possible that the attendance at such a meeting will be small because of the very large number of engineering teachers engaded in active war work. However, the presentation of the various questions, the free discussion and immediate publication will assist everyone in the solution of his own particular problem as well as the general problems which confront every school.

LETTERS TO THE EDITOR.

Dear Sir: An article of mine entitled "Some Factors in Student Scholarship" was printed in the November issue of the Bulletin, p. 98, and a mention was made in it of psychology of study in some of its practical aspects. A number of requests have come to me to explain the last paragraph on

p. 99 more in detail, or to write an article on psychology of study.

May I call the attention of your readers to a small book by Guy Montrose Whipple, professor of education at the University of Illinois, entitled "How to Study Effectively" (Public-School Publishing Co., Bloomington, Ill., 1916). The booklet comprises only 42 pages and consists of 38 definite rules written for high-school students. The rules should also apply well to college students. A bibliography is appended for further reading on the theory of study.

Some day someone may write a similar book for teachers and investigators, showing them on an exact physiological and psychological basis how to plan their life most efficiently for teaching, study, research, social service, recreation and rest. In the meanwhile one has to apply to grown-ups the results of study on children and youths, supplementing it by general works on psychology of attention, memory, perception, etc.

Very truly yours,

V. Karapetoff.

BOOK REVIEWS.

The Composition of Technical Papers. By H. A. Watt. McGraw-Hill Book Co. 1917. 5¼ × 7¾. 431 pages.

This is one of the most satisfactory books which have appeared for use in a course of technical English. The author has assumed that the student is but slightly informed both as to technical theory and as to the principles of composition. Therefore, adopting the conventional arrangement of chapters, he has handled the whole composition, the paragraph, and the sentence concisely and with a judicious selection of none too technical examples. In the chapter on the sentence the simplicity of his treatment is perhaps too elementary, since he has devoted several pages to the grammar-school method of diagramming sentences. In the choice of examples to illustrate paragraph development, he has skilfully shown wherein the methods for constructing the literary paragraph should also apply to the technical. In the articles inserted to make clear the structure of the whole composition, the author has wisely included some that are specifically faulty for correction, as well as a few that shall serve as models. There is a chapter on business letters exceptionally good because the principles deduced are based on the actual practice of careful firms. For use by upperclassmen who have already had training in composition, the text is possibly too elementary; for use by freshmen, the instructor will probably desire to supplement it with a reference book particularly devoted to grammar. If a student wishes independently of a classroom to correct his faulty composition, we can recall no text more complete or clear in serving his purpose.

E. B. B.

The Elements of Non-Euclidean Geometry and Trigonometry. By H. S. CARSLAW. Longmans, Green & Co. 1916. 5 × 7½. 180 pp. $1.50 net.

Non-Euclidean Geometry is written primarily for the use of teachers of elementary geometry. The early chapters of the book are historical in form and treat of Euclid's Parallel Postulate and the work of various men in attempting to prove this theory. In conjunction with this is given a description of the work of Bolyai, Lobatschewsky, and Riemann, the founders of non-Euclidean geometry.

Chapters III–V treat further of the geometry of Bolyai and Lobatschewsky, dealing particularly with the various theorems of parallel constructions.

Chapter V treats of the measurement of length and area, with the aid of the infinitesimal calculus.

Chapters VI–VII are a development of the elliptic geometry while Chapter VIII deals with Poincaré's representation of the non-Euclidean geometries by the geometry of circles orthogonal and diametral to a fixed circle, showing the impossibility of proving the parallel postulate.

The book is terse and the subject-matter at the same time well handled. A large number of theorems are covered for so short a volume.

E. F. L.

COLLEGE NOTES.

Lafayette College.—A revision of the curricula of the courses in chemical, civil, electrical and mechanical engineering has just been effected, the details of which will appear in the forthcoming college catalogue.

In the new curricula special emphasis is laid on the fundamentals. In order to provide ample time for them it was found necessary to reduce the specialized engineering subjects as requirements, though still continuing to offer them and in even fuller measure as electives. Modern languages have been removed from the freshman year as a requirement but are offered later as electives. The entering students are introduced at once to practical engineering problems in mathematics, the work being done in three-hour periods in the presence of the instructor. Surveying is begun at the middle of the freshman year. General electives are offered in the sophomore year, and general and technical electives of wide range in the senior year.

The freshman year will be common to all courses. Differentiation is provided in the sophomore year in the "course subject," coming three periods per week, which will be Qualitative and Quantitative Analysis for Chemical Engineers; Surveying and Railroads for Civil Engineers; Electricity for Electrical Engineers; and Mechanical Technology for Mechanical Engineers. The sophomore elective of three periods per week for both terms may be made in English literature, history or modern languages. It will not be difficult therefore for a student to change his course even as late as the end of the sophomore year.

Especial attention has been given to the planning and coordination of the subject of mechanics, given throughout the junior year. A part of the allotted time will be devoted to the solution of practical problems in three-hour periods under the supervision of the instructor in charge. Economics is given both terms, three periods per week.

Electives will be provided in the senior year in different specialized branches of the course in question; also in economics, government, psychology, history, etc.; and in other engineering subjects not coming strictly within the scope of the particular course. These senior electives amount to nine periods per week for the first term and six for the second.

The degrees offered are B.S. in Ch.E., in C.E., in E.E., and in M.E.

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MEMBERSHIP AND DUTIES OF COMMITTEES OF THE SOCIETY.

1. **Executive Committee:** Milo S. Ketchum, W. O. Wiley and F. L. Bishop.
2. **Publication Committee:** Milo S. Ketchum, G. R. Chatburn and F. L. Bishop.
3. **Program Committee:** Milo S. Ketchum, John F. Hayford, Ira N. Hollis, W. O. Wiley and F. L. Bishop.

   Committees Nos. 1, 2 and 3 have their work defined by the By-Laws of the Society.
4. **Committee on Committees:** Milo S. Ketchum, John F. Hayford, Ira N. Hollis, W. O. Wiley, F. L. Bishop, H. S. Jacoby, C. R. Mann and A. A. Potter.
5. **Joint Committee on Engineering Education:** Representatives from the several organizations. Desmond FitzGerald, *Chairman.*

   Society for the Promotion of Engineering Education: D. C. Jackson and G. C. Anthony.

   American Society of Civil Engineers: Desmond FitzGerald, Onward Bates and D. W. Mead.

   American Society of Mechanical Engineers: F. H. Clark and F. J. Miller.

   American Institute of Electrical Engineers: C. F. Scott and S. Sheldon.

   American Chemical Society: C. Richardson and H. P. Talbot.

   American Institute of Chemical Engineers: J. R. Withrow.

   American Institute of Mining Engineers: H. M. Howe and J. H. Hammond.

   Carnegie Foundation for the Advancement of Teaching: H. S. Pritchett and C. R. Mann.

   General Education Board:
6. **Representative on Joint Committee on Classification of Colleges:** C. S. Howe.

   Committees 4, 5 and 6 have duties indicated by their titles.
7. **Institutional Committee:** John F. Hayford, *Chairman,* Hollis Godfrey, K. G. Matheson, Wm. Easby, Jr., C. S. Howe, P. F. Walker and F. W. Sperr.

   To make a study of catalog descriptions of courses of study.
8. **Committee on Admission:** E. F. Coddington, *Chairman,* H. L. Kent, H. E. Webb.

   Study of the methods of admission to engineering schools including European schools.

9. **Committee on Administration:** Ira N. Hollis, *Chairman,* W. M. Thornton, F. H. Constant, W. M. Riggs, R. W. Gay, O. V. P. Stout, A. H. Fuller.

Occupation of engineering teachers during the summer vacation.

(1) Present status of summer employment.
(2) Opportunities for such employment.
(3) Fields recommended.

10. **Mathematics:** L. C. Plant, *Chairman,* E. J. Berg, E. R. Hedrick, H. E. Cobb, C. S. Slichter.

To what extent does coördination exist between mathematics, physics and mechanics.

11-A. **Committee on Physics:** G. W. Stewart, *Chairman,* F. K. Richtmyer, Barry MacNutt, C. F. Burgess, H. H. Higbie.

Study of the first course in physics.

11-B. **Committee on Chemistry:** R. M. Bird, *Chairman,* J. H. James, J. R. Withrow.

Study of the first course in chemistry.

12. **Committee on English:** C. W. Park, *Chairman,* C. A. Smith, C. F. Park, Frank Aydelotte, J. R. Nelson, P. B. McDonald.

Continue the study of the present status of the teaching of English to engineers.

13. **Committee on Mechanics and Hydraulics:** E. R. Maurer, *Chairman,* Wm. Kent, H. F. Moore, W. T. Magruder, L. M. Hoskins, S. M. Woodward, J. E. Wadsworth.

Continue the work as outlined for the previous year and try to complete the report.

14. **Committee on Economics:** C. C. Williams, *Chairman,* A. B. McDaniel, G. F. Swain, W. G. Raymond, R. H. Fernald.

Continue the work of the previous Committee.

15. **Committee on Civil Engineering:** A. H. Fuller, *Chairman,* W. C. Huntington, H. J. Burt, C. T. Morris, J. Hammond Smith.

Methods and details of teaching structural design.

16. **Committee on Mechanical Engineering:** O. A. Leutwiler, *Chairman,* D. S. Kimball, T. E. French, G. F. Gebhardt, W. T. Magruder.

Methods of teaching machine design.

17. **Committee on Electrical Engineering:** C. F. Harding, *Chairman,* O. J. Ferguson, D. C. Jackson, H. E. Dyche, F. T. Dargan.

A study of the present practice in regard to the teaching of direct currents and alternating currents versus the teaching of the electrical currents.

18. **Committee on Mining Engineering:** F. W. Sperr, *Chairman,* E. A. Holbrook, J. B. Porter, H. H. Stoek, F. A. Thomson.

Continue the work as laid out by the previous committee.

19. **Committee on Co-operation between this Society and the National Association of Corporation Schools:** F. L. Bishop, *Chairman*, R. L. Sackett, W. C. Bauer.

    Duties defined by title.

20. **Committee on the Standardization of Technical Nomenclature:** J. T. Faig, *Chairman*, W. D. Ennis, F. N. Raymond, Chas. Warren Hunt.

21. **Committee on Military Engineering:** L. S. Randolph, *Chairman*, C. S. Sperry, Jr., J. N. Bridgman, C. J. Tilden, H. S. Boardman.

    Military instruction to engineering students during the war.

Special War Committee: Milo S. Ketchum, *Chairman*, G. C. Anthony, F. L. Bishop, S. P. Capen, Robt. Fletcher, Hollis Godfrey, J. F. Hayford, Ira N. Hollis, C. S. Howe, D. C. Jackson, F. W. McNair, C. R. Mann, Mansfield Merriman, W. G. Raymond, C. Russ Richards, G. F. Swain, Wm. M. Thornton, F. E. Turneaure.

OFFICERS 1917–18.

President.

Milo S. Ketchum, Boulder, Colo.

Vice-Presidents.

John F. Hayford, Evanston, Ill.

Ira N. Hollis, Worcester, Mass.

Secretary.

F. L. Bishop, Pittsburgh, Pa.

Treasurer.

Wm. O. Wiley, 432 Fourth Ave.,
New York, N. Y.

COUNCIL.

Elective Members.

L. P. Breckenridge, New Haven, Conn.
C. L. Cory, Berkeley, Cal.
C. H. Crouch, Grand Forks, N. D.
O. P. Hood, Pittsburgh, Pa.
F. P. McKibben, Bethlehem, Pa.
G. D. Shepardson, Minneapolis, Minn.
J. B. Whitehead, Baltimore, Md.

Terms expire in 1918.

A. H. Blanchard, New York, N. Y.
W. H. Browne, Jr., West Raleigh, N. C.
T. E. French, Columbus, Ohio.
R. W. Gay, Agricultural College, Miss.
F. G. Higbee, Iowa City, Ia.
E. J. McCaustland, Columbia, Mo.
A. A. Potter, Manhattan, Kans.

Terms expire in 1919.

T. U. Taylor, Austin, Tex.
K. G. Matheson, Atlanta, Ga.
C. J. Tilden, Baltimore, Md.
C. F. Scott, New Haven, Conn.
Frank Aydelotte, Cambridge, Mass.
W. E. Mott, Pittsburgh, Pa.
L. M. Hoskins, Palo Alto, Calif.

Terms expire in 1920.

Past-Presidents—Members Ex-Officio.

G. F. Swain, Cambridge, Mass.
Mansfield Merriman, N. Y., N. Y.
H. T. Eddy, Minneapolis, Minn.
T. C. Mendenhall, Ravenna, O.
Ira O. Baker, Urbana, Ill.
D. C. Jackson, Cambridge, Mass.
Chas. S. Howe, Cleveland, O.
F. E. Turneaure, Madison, Wis.
H. S. Munroe, Litchfield, Conn.
A. N. Talbot, Urbana, Ill.
Robert Fletcher, Hanover, N. H.
C. Frank Allen, Boston, Mass.
F. W. McNair, Houghton, Mich.
W. G. Raymond, Iowa City, Ia.
W. T. Magruder, Columbus, O.
G. C. Anthony, Tufts College, Mass.
Anson Marston, Ames, Ia.
Henry S. Jacoby, Ithaca, N. Y.
G. R. Chatburn, Lincoln, Nebr.

LIST OF INSTITUTIONAL MEMBERS.

Municipal University of Akron, College of Engineering, Akron, O., Fred. E. Ayer, Dean	1914
Alabama Polytechnic Institute, Auburn, Ala., Chas. C. Thach, President	1914
University of Arizona, Tucson, Ariz., von KleinSmid, President	1914
Brown University, Providence, R. I., W. H. P. Faunce, President.	1914
University of California, Berkeley, Calif., Benjamin Ide Wheeler, President	1913
Carnegie Institute of Technology, Pittsburgh, Pa., A. A. Hamerschlag, President	1915
Case School of Applied Science, Cleveland, O., Chas. S. Howe, President	1913
Catholic University of America, Washington, D. C., Thomas J. Shahan, Rector	1917
The Citadel, The Military College of South Carolina, Charleston, S. C., O. J. Bond, Supt.	1914

INSTITUTIONAL MEMBERS.

Clemson A. & M. College, Clemson College, S. C., W. M. Riggs, President	1913
University of Cincinnati, Cincinnati, O., Wm. Dabney, President	1917
Colorado School of Mines, Golden, Colo., Victor C. Alderson, President	1915
University of Colorado, Boulder, Colo., Livingston Farrand, President	1915
Cornell University, Ithaca, N. Y., Jacob Gould Schurman, President	1913
Delaware College, Newark, Del., S. C. Mitchell, President	1916
Drexel Institute, Philadelphia, Pa., Hollis Godfrey, President	1914
Ecole Polytechnique, Montreal, Canada	1917
The George Washington University, Washington, D. C., Chas. H. Stockton, President	1913
Georgia School of Technology, Atlanta, Ga., K. G. Matheson, President	1913
Iowa State College, Ames, Ia., Raymond A. Pearson, President.	1913
State University of Iowa, Iowa City, Ia., Walter A. Jessup, President	1914
Junior College of The Crane Technical High School, Chicago, Ill., Wm. J. Bartholf, Principal	1915
Kansas State Agricultural College, Manhattan, Kans., Henry J. Waters, President	1915
The University of Kansas, Lawrence, Kans., Frank Strong, Chancellor	1914
Lafayette College, Easton, Pa., J. H. MacCracken, President	1915
Lehigh University, South Bethlehem, Pa., Henry S. Drinker, President	1914
Leland Stanford Jr. University, Stanford University, Calif., J. L. Wilbur, President	1917
University of Maine, Orono, Me., Robt. J. Aley, President	1917
Miami University, Oxford, O., R. M. Hughes, President	1913
Michigan College of Mines, Houghton, Mich., F. W. McNair, President	1914
University of Michigan, Ann Arbor, Mich., H. B. Hutchins, President	1913
University of Missouri, Columbia, Mo., A. Ross Hill, President.	1914
University of Nebraska, Lincoln, Nebr., Samuel Avery, Chancellor.	1914
New Mexico College of A. & M. Arts, State College, N. M., G. E. Ladd, President	1917
New York University, New York, N. Y., Elmer E. Brown, President	1913
University of North Carolina, Chapel Hill, N. C., E. K. Graham, President	1917

The University of North Dakota, Grand Forks, N. D., Frank L. McVey, President	1913
University of Notre Dame, Notre Dame, Ind., John Cavanaugh, President	1913
State University of Oklahoma, Norman Okla., Stratton D. Brooks, President	1913
Oregon Agricultural College, Corvallis, Ore., W. J. Kerr, President	1917
The Pennsylvania State College, State College, Pa., Edwin E. Sparks, President	1914
University of Pennsylvania, Philadelphia, Pa., Edgar F. Smith, Provost	1914
University of Pittsburgh, Pittsburgh, Pa., Samuel B. McCormick, Chancellor	1913
Purdue University, LaFayette, Ind., W. E. Stone, President	1915
Rhode Island State College, Kingston, R. I., Howard Edwards, President	1913
Rose Polytechnic Institute, Terre Haute, Ind. John White, President	1916
Rutgers College, New Brunswick, N. J., W. H. S. Demarest, President	1914
Sheffield Scientific School of Yale University, New Haven, Conn., R. H. Chittenden, Director	1917
University of South Carolina, Columbia, S. C., S. C. Mitchell, President	1914
Stevens Institute of Technology, Hoboken, N. J., A. C. Humphreys, President	1913
Syracuse University, Syracuse, N. Y., James R. Day, Chancellor.	1913
A. & M. College of Texas, College Station, Tex. Wm. Bennet Bizzell, President	1916
Throop College of Technology, Pasadena, Calif., Jas. A. B. Scherer, President	1913
Toledo University, Toledo, O., A. M. Stowe, President	1915
University of Toronto, Toronto, Ont., Canada, R. A. Falconer, President	1917
Tufts College, Tufts College, Mass., Hermon C. Bumpus, President	1914
U. S. Naval Academy, Annapolis, Md., Captain E. W. Eberle, Superintendent	1913
University of Utah State School of Mines, Salt Lake City, Utah, J. F. Kingsbury, President	1914
Vanderbilt University, Nashville, Tenn., J. H. Kirkland, Chancellor	1914
University of Vermont, Burlington, Vt., Guy Potter Benton, President	1915

University of Virginia, University, Va., Edwin A. Alderman, President	1915
Washington University, St. Louis, Mo., David F. Houston, Chancellor	1914
University of Washington, Seattle, Wash., Henry Suzzallo, President	1913
Wentworth Institute, Boston, Mass., A. L. Williston, Principal	1917
University of Wisconsin, Madison, Wis., Chas. R. Van Hise, President	1914
Worcester Polytechnic Institute, Worcester, Mass., Ira N. Hollis, President	1913

LIST OF INDIVIDUAL MEMBERS.

Revised to March 1st, 1918.

ACKER, M. W., Instructor in charge of Machine Shops, David Ranken, Jr., School of Mechanical Trades, St. Louis, Mo. 1913

ADAMS, COMFORT, A., Abbott and James Lawrence Professor of Engineering, Harvard University, and Massachusetts Institute of Technology, Cambridge, Mass. 1894

ADAMS, FRANK D., Dean of the Faculty of Applied Science, McGill University, Montreal, Canada.............................. 1909

ADAMS, F. J., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1912

ADAMS, W. H., Professor of Mechanical Engineering, Throop College of Technology, Pasadena, Calif. 1908

ADAMSON, K. F., Assistant Professor of Mechanical Engineering, Case School of Applied Science, Cleveland O. 1912

ADELSPERGER, ROLLAND, Professor of Architecture and Architectural Engineering, Texas A. & M. College, College Station, Tex. 1914

ADLER, A. A., Assistant Professor of Mechanical Drawing and Design, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1910

AGG, T. R., Professor of Highway Engineering, Iowa State College, Ames, Ia. 1915

AKELEY, L. E., Dean of the College of Engineering and Professor of Physics, University of South Dakota, Vermilion, S. D.... 1910

ALBERT, C. E., Civil Engineer, Camden Iron Works, Camden, N. J. 1914

ALDRICH, WM. S., Associate Professor of Electrical Engineering, Colorado Agricultural College, Fort Collins, Colo. 1893

ALEXANDER, MAGNUS W., Consulting Engineer, General Electric Co., Managing Director, National Industrial Conference Board, Boston, Mass. 1911

ALLEE, W. G., Instructor in Physics, Kansas State Agricultural College, Manhattan, Kans. 1915

ALLEN, C. F., 88 Montview St., West Roxbury, Mass. 1893

ALLEN, CHESTER, Burton F. Blough Professor of Civil Engineering, Pennsylvania College, Gettysburg, Pa. 1917

ALLEN, C. M., Professor of Hydraulic Engineering, Worcester Polytechnic Institute, Worcester, Mass.......................... 1903

ALLEN, F. G., Assistant Professor in General Engineering Drawing, University of Colorado, Boulder, Colo. 1913

LIST OF MEMBERS.

Allen, J. R., Dean, Engineering Department, University of Minnesota, Minneapolis, Minn. 1907

Allison, W. F., Professor of Municipal and Highway Engineering, University of Washington, Seattle, Wash. 1915

Anderson, A. H., Associate Professor of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. 1910

Anderson, D. S., Professor of Electrical Engineering, Tulane University, New Orleans, La. 1900

Anderson, F. Paul, Dean of the College of Mechanical and Electrical Engineering, Professor of Mechanical Engineering and Director of the Experiment Engineering Laboratories, University of Kentucky, Lexington, Ky. 1894

Anderson, G. G., Consulting Civil Engineer, 336–337 Consolidated Realty Bldg., Los Angeles, Cal. 1910

Anderson, R. J., Instructor in Metallurgy, Missouri School of Mines, Rolla, Mo. 1915

Anderson, William, Assistant Professor of Mechanical Engineering, Michigan College of Mines, Houghton, Mich. 1910

Andrews, W. H., Associate Professor of Mathematics, Kansas State Agricultural College, Manhattan, Kans. 1912

Andros, S. O., Executor M. W. Flournoy Estate, Albuquerque, N. M. 1913

Angel, Wm. P., Assistant Professor of Physics, Oklahoma A. &. M. College, Stillwater, Okla. 1914

Anthony, G. C., Professor of Technical Drawing and Dean of the Engineering School, Tufts College, Tufts College, Mass. 1896

Appleby, W. R., Dean of the Minnesota School of Mines and Professor of Metallurgy, University of Minnesota, Minneapolis, Minn. 1913

Appleton, W. D., Mechanical Engineer, The Guanajuato Power and Electric Co., Zamora, Michoacan, Mexico 1907

Applin, Samuel, Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912

Ard, C. E., Consulting and Contracting Engineer, 402 American Trust Bldg., Birmingham, Ala. 1911

Arkley, L. M., Assistant Professor of Mechanical Engineering, University of Toronto, Toronto, Canada 1908

Armsby, Henry H., Instructor in Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. 1917

Arnett L. D., Librarian, West Virginia University, Morgantown, W. Va. 1915

Arnold, Bion J., Consulting Electrical Engineer, 105 S. La Salle St., Chicago, Ill. 1906

ASHTON, C. H., Professor of Mathematics, University of Kansas, Lawrence, Kans.	1915
ASTON, JAMES, Bureau of Mines, 40th & Butler Sts., Pittsburgh, Pa.	1910
ATKINSON, F. W., President of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y.	1905
ATKINSON, THOS. W., Dean of the College of Engineering, Louisiana State University, Baton Rouge, La.	1907
AUDE, H. T. R., Assistant Professor of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pa.	1910
AUSTIN, F. E., Professor of Electrical Engineering, Dartmouth College, Hanover, N. H.	1912
AVRAM, M. H., Lecturer on Industrial Engineering, New York, University, New York, N. Y.	1918
AYARS, W. S., Professor of Electrical and Mechanical Engineering, Nova Scotia Technical College, Principal Re-Education Dept., Military Hospitals Commission, Canada, Halifax, N. S.	1907
AYDELOTTE, FRANK, Professor of English, Massachusetts Institute of Technology, Cambridge, Mass.	1915
AYER, A. W., Factory Manager, Midland Chemical Co., Chicago, Ill.	1894
AYER, FRED. E., Dean College of Engineering, and Professor of Civil Engineering, Municipal University of Akron, Akron, O.	1907
AYRES, BROWN, President of The University of Tennessee, Knoxville, Tenn.	1898
BABBITT, ARTHUR B., Head of the Department of Drawing and Design, Wentworth Institute, Boston, Mass.	1912
BABCOCK, E. J., Dean of the College of Engineering and Acting President, Professor of Industrial Chemistry and Metallurgy and Director of Experimental Engineering Stations, University of North Dakota, Grand Forks, N. D.	1907
BACHE-WIIG, Jens, Professor of Electrical Engineering, Norwegian Technical University, Trondhjem, Norway, Europe	1914
BACON, G. M., Civil Engineer, 311 Newhouse Bldg., Salt Lake City, Utah	1907
BAEBENROTH, A. C., Professor and Head of Department of English, College of Applied Science, Syracuse University, Syracuse, N. Y.	1915
BAENDER, F. G., Professor of Heat Power Engineering, Supt., Mechanic Arts, State University of Arkansas, Fayetteville, Ark.	1917
BAILEY, A. R., Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.	1915
BAINBRIDGE, G. H., Instructor, Dept. of Mathematics and Surveying, Rensselaer Polytechnic Institute, Troy, N. Y.	1916

Baker, Cecil F., Professor of Architecture, Kansas State Agricultural College, Manhattan, Kans. 1917

Baker, Ira O., Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1893

Ball, Albert, Professor of Physics, Cooper Union, New York, N. Y. 1908

Bankson, E. E., Civil Engineer, with Chester & Fleming, Hydraulic and Sanitary Engineers, Pittsburgh, Pa. 1910

Barba, C. E., Supt. Mobile Artillery Shops, Midvale Steel Co., Philadelphia, Pa. 1915

Bark, Elmer, Power Engineer, The Barrett Co. (Chemical Dept.), Frankford, Pa. 1912

Barnard, W. N., Professor of Power Engineering, Cornell University, Ithaca, N. Y. 1910

Barnes, A. F., Dean School of Engineering, New Mexico College of A. & M. Arts, State College, New Mex. 1914

Barnes, F. A., Professor of Railroad Engineering, Cornell University, Ithaca, N. Y. 1904

Barney, Edgar S., Principal, Hebrew Technical Institute, 36 Stuyvesant St., New York, N. Y. 1912

Barney, S. E., Assistant Professor of Civil Engineering, Yale University, New Haven, Conn. 1894

Barraclough, S. H. E., Professor of Mechanical Engineering, University of Sydney, Sydney, Australia. 1900

Barrows, H. K., Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1902

Barrows, W. E. Jr., Professor of Electrical Engineering, University of Maine, Orono, Me. 1908

Bartholomew, H. C., Associate Professor of Electrical Engineering, Iowa State College, Ames, Ia. 1915

Barton, E. C., Engineer and Manager, City Electric Light Co., Brisbane, Queensland, Australia 1914

Basquin, O. H., Professor of Applied Mechanics, Northwestern University, Evanston, Ill. 1908

Bass, Frederic, Professor of Municipal and Sanitary Engineering, University of Minnesota, Minneapolis, Minn. 1904

Bates, J. T., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Ia. 1912

Bates, Onward, Civil Engineer, 332 S. Michigan Ave., Chicago, Ill. 1903

Bauer, F. S., Assistant Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. 1914

Bauer, W. C., Professor of Electrical Engineering, Northwestern University, Evanston, Ill. 1910

BAUM, WM., Dean, School of Engineering of Milwaukee, Milwaukee, Wis.	1916
BEAVER, J. L., Assistant Professor of Electrical Engineering, Lehigh University, Bethlehem, Pa.	1914
BECKER, A. J., Professor of Applied Mathematics, University of North Dakota, Grand Forks, N. D.	1907
BEACH, ROBIN, Professor of Electrical Engineering, Norwich University, Northfield, Vt.	1917
BEGGS, G. E., Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J.	1915
BELL, J. M., Professor of Physical Chemistry, University of North Carolina, Chapel Hill, N. C.	1914
BELLIS, A. E., Professor of Physics, University of Wyoming, Laramie, Wyo.	1914
BENEDICT, B. W., Director of Shop Laboratories, University of Illinois, Urbana, Ill.	1912
BENEDICT, H. G., Works Manager, The Glenn L. Martin Company, Cleveland, O.	1913
BENEDICT, H. Y., Professor of Applied Mathematics and Dean of the College of Arts, University of Texas, Austin, Texas	1906
BENJAMIN, C. H., Dean of the Schools of Engineering and Director, Engineering Experiment Station, Purdue University, La-Fayette, Ind.	1893
BENKERT, H. N., Professor of Civil Engineering, Drexel Institute, Philadelphia, Pa.	1909
BENNETT, EDW., Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.	1909
BENTON, J. R., Professor of Physics and Electrical Engineering, and Dean of the College of Engineering, University of Florida, Gainesville, Fla.	1905
BENZENBERG, G. H., Consulting Civil Engineer, Retired, 255 Greenbush St., Milwaukee, Wis.	1907
BERARD, S. J., Instructor in Machine Design, Yale University, New Haven, Conn.	1912
BERENTS, H., Consulting Civil Engineer, 13 Nanking Road, Shanghai, China	1911
BERG, E. J., Professor of Electrical Engineering, Union University, Schenectady, N. Y.	1910
BERGER, F. A., Assistant Professor of Mechanical Engineering, Washington University, St. Louis, Mo.	1910
BERRESFORD, A. W., Vice-President and General Manager, The Cutler-Hammer Mfg. Co., Milwaukee, Wis.	1911
BERRY, H. C., Professor of Materials of Construction, University of Pennsylvania, Philadelphia, Pa.	1916

Berry, W. J., Associate Professor of Mathematics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1910

Betts, Philander, Chief Engineer, Public Utility Commission of New Jersey, Newark, N. J. 1907

Bevan, W. A., Assistant Professor of Physics, Oregon Agricultural College, Corvallis, Ore. 1915

Beyer, S. W., Dean of the Division of Engineering and Professor of Geology and Mining Engineering, Iowa State College, Ames, Ia. 1899

Biegler, P. S., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1908

Bierma, A. G., Professor in charge of Mechanical Engineering, University of Detroit, Detroit, Mich. 1913

Bikle, J. S., Instructor in Mathematics, Bradley Polytechnic Institute, Peoria, Ill. 1918

Billmyer, Carroll D., Instructor in Mechanical Engineering, Throop College of Technology, Pasadena, Calif. 1911

Bird, H. C., Professor of Civil Engineering, Pennsylvania Military College, Chester, Pa. 1914

Bird, R. M., Professor of Chemistry, University of Virginia, University, Va. 1915

Bird, Wm. W., Professor of Mechanical Engineering, and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass. 1910

Bishop, C. T., Assistant Professor of Structural Engineering, Yale University, New Haven, Conn. 1912

Bishop, F. L., Dean School of Engineering, Professor of Physics, University of Pittsburgh, Pittsburgh, Pa. 1907

Bissell, G. W., Dean of Engineering, Michigan Agricultural College, East Lansing, Mich. 1894

Bitting, H. S., President of the Williamson Free School of Mechanical Trades, Williamson School, Delaware Co., Pa. 1909

Black, R. M., Associate Professor of Mining, University of Pittsburgh, Pittsburgh, Pa. 1912

Blackburn, H. W., Instructor, Wentworth Institute, Boston, Mass. 1912

Blake, Frederic C., Professor of Physics, The Ohio State University, Columbus, O. 1918

Blakeslee, D. W., Electrical Engineer and Assistant Supt., Penn Electrical and Mfg. Co., Irwin, Pa. 1914

Blanchard, A. H., Consulting Highway Engineer, Broadway and 117th St., New York, N. Y. 1902

Bland, J. C., Engineer of Bridges, Pennsylvania Lines West of Pittsburgh, Room 520, Penna. Station, Pittsburgh, Pa. 1911

BLESSING, G. F., Professor of Mechanical Engineering, in charge of Engineering, Swarthmore College, Swarthmore, Pa. 1910

BLISS, COLLINS P., Professor of Mechanical Engineering, New York University, University Heights, New York City 1915

BLOEMKER, CHAS. W., Instructor in Forging, University of Pennsylvania, Philadelphia, Pa. 1912

BLUME, L. F., Electrical Engineer, General Electric Co., Pittsfield, Mass. 1911

BOARDMAN, H. P., Professor of Civil Engineering, University of Nevada, Reno, Nev. 1914

BOARDMAN, H. S., Dean of the College of Technology and Professor of Civil Engineering, University of Maine, Orono, Me........ 1903

BOGARD, FRANK, Supt., Mechanical and Electrical Engineering Courses, Louisiana Industrial Institute, Ruston, La. 1914

BOLTON, F. C., Professor of Electrical Engineering, A. and M. College of Texas, College Station, Texas 1910

BOOMSLITER, G. P., Associate in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1912

BOOTHROYD, S. L., Associate Professor of Astronomy, University of Washington, Seattle, Wash. 1908

BOWERMAN, M. R., Checker, Alliance Machine Co., Alliance, O. ... 1909

BOYD, ALFRED, Dean, School of Engineering, and Professor of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1909

BOYD, J. E., Professor of Mechanics, The Ohio State University, Columbus, O. 1907

BOYER, F. Q., Engineer of Tests, The H. B. Smith Co., Westfield, Mass. 1912

BOYLE, A. C., JR., Professor of Mining Engineering and Economic Geology, University of Wyoming, Laramie, Wyo. 1911

BOZELL, H. V., Assistant Professor of Electrical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn. ... 1912

BRACKETT, B. B., Professor of Electrical Engineering, South Dakota State College of A. and M. Arts, Brookings, S. D. 1906

BRADFORD, J. N., Professor of Architecture and University Architect, The Ohio State University, Columbus, O. 1896

BRASEFIELD, S. E., Professor of Applied Mathematics, Rutgers College, New Brunswick, N. J. 1916

BRATTON, W. A., Professor of Mathematics and Dean of Science Group, Whitman College, Walla Walla, Wash. 1911

BRAUNE, G. M., Assistant Professor of Civil Engineering, University of Cincinnati, Cincinnati, Ohio......................... 1914

BRAY, H. C. C., Instructor to the Apprentices, Nova Scotia Steel and Coal Co., Ltd., New Glasgow, Nova Scotia, Canada 1916

BRECKENRIDGE, L. P., Professor of Mechanical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.... 1893

BREED, C. B., Professor of Railroad Engineering, Massachusetts Institute of Technology, Boston, Mass. 1904

BRIDGMAN, J. N., Associate Professor of Civil Engineering, University of Nebraska, Lincoln, Neb. 1913

BRINGHURST, J. H., Associate in Civil Engineering, Johns Hopkins University, Baltimore, Md. 1915

BRODIE, HUGH, Assistant Professor of Surveying, University of Michigan, Ann Arbor, Mich. 1915

BROOKE, W. E., Head of Department of Mathematics and Mechanics, College of Engineering, University of Minnesota, Minneapolis, Minn. 1902

BROOKS, J. ANSEL, Associate Professor of Mechanics and Mechanical Drawing, Brown University, Providence, R. I. 1904

BROOKS, J. P., President, Clarkson College of Technology, Potsdam, N. Y. 1898

BROOKS, MORGAN, Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1899

BROWN, A. I., Assistant Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. 1914

BROWN, CARROLL G., Laboratory Director, Rochester Railway & Light Co., Rochester, N. Y. 1914

BROWN, CHAS. B., Professor of Civil Engineering, University of Maine, Orono, Me. 1912

BROWN, F. L., Assistant Professor of Mechanics, University of Kansas, Lawrence, Kans. 1915

BROWN, HENRY B., President, Valparaiso University, Valparaiso, Ind., ... 1908

BROWN, H. W., Electrical Engineer, General Electric Co., Schenectady, N. Y. 1916

BROWN, J. M., Professor of Civil Engineering, University of South Dakota, Vermillion, S. D. 1916

BROWN, (Mrs.) KATHARINE D., Professor of Technical English, Drexel Institute, Philadelphia, Pa. 1914

BROWN, R. A., Instructor in Electrical Engineering, The Ohio State University, Columbus, O. 1917

BROWN, S. L., Associate Professor of Physics, University of Texas, Austin, Tex. 1914

BROWNE, EDWARD T., Instructor in Mathematics, University of Virginia, University, Va. 1915

BROWNE, WM. HAND, JR., Professor of Electrical Engineering, North Carolina College of A. and M. Arts, West Raleigh, N. C. 1899

BRYANS, W. R., Associate Professor in the School of Applied Science, New York University, New York, N. Y. 1908

BRYANT, J. M., President Academic Board, U. S. Army, School Military Aeronautics, University of Texas, Austin, Tex. 1910

BRYDONE-JACK, E. E., Superintending Engineer, Public Works of Canada, Winnipeg, Man. 1902

BUCK, A. M., Consulting Engineer with J. A. Beeler, 52 Vanderbilt Ave., New York, N. Y. 1910

BULLOCK, W. E., Managing Editor, American Society of Mechanical Engineers, New York, N. Y. 1917

BUMP, M. R., Chief Engineer, Henry L. Doherty & Co., 60 Wall St., New York, N. Y. 1907

BURGER, W. H., Professor of Civil Engineering, Northwestern University, Evanston, Ill. 1910

BURNSIDE, C. H., Associate Professor of Mechanics, Columbia University, New York, N. Y. 1910

BURPEE, F. E., Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pa. 1910

BURR, W. H., Emeritus Professor of Civil Engineering, Columbia University, Consulting Engineer, 120 Broadway, New York, N. Y. 1893

BURSLEY, J. A., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1910

BURT, H. J., Structural Engineer, Holabird & Roche, Architects, 1027 Elmwood Ave., Wilmette, Ill. 1910

BURTON, A. E., Professor of Topographical Engineering, in charge of Department of Drawing, and Dean of the Massachusetts Institute of Technology, Cambridge, Mass. 1904

BUSH, VANNEVAR, Assistant Professor of Electrical Engineering Tufts College, Tufts College, Mass. 1917

BUTLER, G. M., Dean, College of Mines and Engineering, University of Arizona, Tucson, Ariz. 1916

BUTTERFIELD, A. D., Professor of Mathematics and Geodesy, Worcester Polytechnic Institute, Worcester, Mass. 1908

CAJORI, FLORIAN, Dean of the Department of Engineering, Professor of Mathematics, Colorado College, Colorado Springs, Colo. 1904

CALDWELL, EDWARD, Treasurer of the McGraw-Hill Book Co., Inc., 239 W. 39th St., New York, N. Y. 1905

CALDWELL, F. C., Professor of Electrical Engineering, The Ohio State University, Columbus, O. 1897

CALLAN, J. A. C., Assistant Professor of Surveying and Drawing, Union University, Schenectady, N. Y. 1909

CALLAN, JOHN G., Professor of Steam and Gas Engineering, University of Wisconsin, Madison, Wis. 1917

CALNAN, J. W., Instructor in charge of Department of Chemistry, Franklin Union, Boston, Mass. 1910

CAMPBELL, T. P., Dean, General Faculty, Virginia Polytechnic Institute, Blacksburg, Va. 1917

CANNON, J. H., Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1915

CAPEN, S. P., Specialist in Higher Eudcation, Bureau of Education, Washington, D. C. 1917

CARLSON, W. W., Professor of Shop Practice and Superintendent of Shops, Kansas State Agricultural College, Manhattan, Kans. 1912

CARNEGIE, ANDREW, 2 E. 91st St., New York, N. Y. (Life Member). 1911

CARPENTER, H. D., 10759 Prospect Ave., Chicago, Ill. 1910

CARPENTER, Hubert V., Professor of Mechanical and Electrical Engineering, Dean, College of Mechanic Arts and Engineering, State College of Washington, Pullman, Wash. 1917

CARPENTER, L. G., Consulting Engineer, 707 First National Bank Bldg., Denver, Colo. 1895

CARPENTER, RANDLE C., Professor of Mechanical Engineering, Mississippi A. & M. College, Agricultural College, Miss. 1914

CARREL, W. J., Associate Professor of Civil Engineering, University of Kentucky, Lexington, Ky. 1917

CARROLL, H. H., Assistant Professor Technical Drawing, Tufts College, Tufts College, Mass. 1911

CARSON, W. W., Emeritus Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. 1894

CARTER, H. G., Assistant Electrical Engineer, Public Works Department, Sydney, New South Wales, Australia 1914

CARTY, J. J., Chief Engineer, American Telephone and Telegraph Co., 195 Broadway, New York, N. Y. 1907

CASE, G. W., Professor of Sanitary Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

CATLIN, W. G., Electrical Engineer, Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. 1912

CAUGHEY, R. A., Assistant Professor of Civil Engineering, Pennsylvania State College, State College, Pa. 1911

CHANDLER, E. F., Professor of Civil Engineering, and in charge of Civil Engineering Course, University of North Dakota, University, N. D. 1907

CHANEY, GEO. A., Associate Professor of Mathematics, Iowa State College, Ames, Ia. 1914

CHAPMAN, L. B., Engineer, Electric Boat Company, New London, Conn. 1917

CHARAVAY, M. A., Assistant Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. 1914

CHARLES, ROLLIN L., Assistant Professor of Physics, Lehigh University, Bethlehem, Pa. 1914

CHASE, C. H., Professor of Steam Engineering, Tufts College, Tufts College, Mass. 1900

CHASE, LEON W., Professor of Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 1910

CHATBURN, G. R., Professor and Head of the Department of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebr. 1899

CHEDSEY, W. R., Assistant Professor of Mining, Colorado School of Mines, Golden, Colo. 1915

CHESNEY, C. C., Manager and Chief Engineer, General Electric Co., Pittsfield, Mass. 1911

CHRISTENSEN, GEO. L., Professor of Mechanical Engineering, Michigan College of Mines, Houghton, Mich. 1905

CHRISTIAN, J. W., Mechanical Engineer, 917 E. 11th Ave., Denver, Colo. 1914

CHURCH, E. F., JR., Professor of Machine Design and Construction, West Virginia University, Morgantown, W. Va. 1910

CHURCH, I. P., Emeritus Professor of Applied Mechanics and Hydraulics, Cornell University, Ithaca, N. Y. 1910

CLAPP, W. H., Associate Professor of Mechanism and Machine Design, Throop College of Technology, Pasadena, Calif. 1914

CLARK, J. C., Assistant Professor of Electrical Engineering, Leland Stanford Jr. University, Stanford University, Calif. 1912

CLARKSON, R. P., Consulting Engineer, General Manager, Safety Service Corporation, 29 Broadway, New York, N. Y. 1915

CLEGHORN, M. P., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Ia. 1910

CLIFFORD, H. E., Gordon McKay Professor of Electrical Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass. 1907

CLIFTON, H. T., Teacher in Physics and Geology, and Registrar, Pasadena High School, Pasadena, Calif. 1907

COAHRAN, J. M., Professor of Electrical Engineering, Villanova College, Villanova, Pa. 1916

COATES, ARTHUR B., Instructor in Mechanical Engineering, Unisity of Idaho, Moscow, Ida. 1918

COBB, COLLIER, Professor and Head of the Department of Geology and Mineralogy, University of North Carolina, Chapel Hill, N. C. 1916

COBB, H. E., Professor and Head of Department of Mathematics, Lewis Institute, Chicago, Ill. 1908

CODDINGTON, E. F., Acting Dean, College of Engineering, Professor of Mechanics, The Ohio State University, Columbus, O. 1911

CODWISE, H. R., Assistant Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1914

COFFIN, C. A., Chairman, Board of Directors, General Electric Co., 120 Broadway, New York, N. Y. 1911

COLE, ALFRED D., Professor of Physics, Head of Department, The Ohio State University, Columbus, O. 1918

COMSTOCK, C. E., Professor of Mathematics, Bradley Polytechnic Institute, Peoria, Ill. 1909

COMSTOCK, E. H., Professor of Mine Plant and Mechanics, School of Mines, University of Minnesota, Minneapolis, Minn. 1907

COMSTOCK, F. M., Professor of Descriptive Geometry, Case School of Applied Science, Cleveland, O......................... 1907

CONKLING, L. D., Professor of Civil Engineering, Montana State A. & M. College, Bozeman, Mont. 1912

CONNER, S. L., Assistant Professor of Railroad Engineering, Tufts College, Tufts College, Mass. 1912

CONRAD, L. E., Professor of Civil Engineering, Kansas State Agricultural College, Manhattan, Kans. 1908

CONSOLIVER, EARL L., Instructor in Mechanical Drawing and Machine Design, University of Wisconsin, Madison, Wis. 1918

CONSTANT, F. H., Professor of Civil Engineering, Princeton University, Princeton, N. J. 1896

COOK, A. L., Head of the Dept. of Applied Electricity, Pratt Institute, Brooklyn, N. Y. 1913

COOK, PAUL, President of W. & L. E. Gurley, and Treasurer of Rensselaer Polytechnic Institute, Troy, N. Y. 1913

COOK, ROBERTSON, Professor of Experimental Engineering, South Dakota State College, Brookings, S. D...................... 1913

COOKE, M. L., Consulting Engineer, 401 W. Walnut Lane, Germantown, Philadelphia, Pa. 1910

COOLEY, M. E., Professor of Mechanical Engineering and Dean of the Colleges of Engineering and Architecture, University of Michigan, Ann Arbor, Mich. 1893

COOMBS, S. E., Special Engineer, N. Y. C. & H. R. R. R. and Instructor in Mechanical Drawing, New York Evening High School for Men, Room 5613, Grand Central Terminal, New York, N. Y. 1913

COOPER, F. E., Management Engineer, with Boyden & Steacie, Boston, Mass. 1915

COOPER, F. L., Instructor in Physics, Yale University, New Haven, Conn. 1912

Coppersmith, C. W., Assistant Professor of Machine Design, Case School of Applied Science, Cleveland, O. 1915

Corbett, L. J., Professor of Electrical Engineering, University of Idaho, Moscow, Ida. 1912

Corbin, C. E., Professor of Engineering and Applied Mathematics, College of the Pacific, San Jose, Calif. 1917

Cornell, W. R., Instructor in Applied Mechanics, Cornell University, Ithaca, N. Y. 1910

Corp, C. I., Associate Professor of Hydraulic Engineering, University of Wisconsin, Madison, Wis. 1910

Cory, C. L., Dean, College of Mechanics and Professor of Electrical Engineering, University of California, Berkeley, Calif........ 1915

Coster, E. L., Literary Engineer, 25 Broad St., Room 1440, New York, N. Y. (Life Member) 1911

Covell, G. A., Dean of the School of Engineering and Mechanic Arts, Oregon Agricultural College, Corvallis, Ore............ 1908

Cox, J. J., Assistant Professor of Civil Engineering, in charge of Highway Engineering, University of Michigan, Ann Arbor, Mich. 1915

Crain, L. D., Professor of Mechanical Engineering, Head of Department, Colorado Agricultural College, Ft. Collins, Colo. ... 1918

Crandell, John S., Consulting Engineer, The Barrett Co., 17 Battery Place, New York, N. Y. 1912

Crane, H. G., Manufacturer of Electrical and Mechanical Apparatus, Brookline, Mass. 1908

Crawford, D. F., General Manager, Pennsylvania Lines, and Director of Railway Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

Crawford, I. C., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1913

Creagmile, Wm. B., School of Engineering, Drexel Institute, Philadelphia, Pa. 1909

Creighton, E. E. F., Consulting Engineer, General Electric Co., Schenectady, N. Y. 1910

Creighton, W. H. P., Dean of the College of Technology and Professor of Mechanical and Sugar Engineering, Tulane University, New Orleans, La. 1893

Crockett, Chas. W., Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute, Troy, N. Y. 1912

Crosby, W. W., Consulting Engineer, Baltimore, Md. 1911

Cross, Hardy, Assistant Professor of Civil Engineering, Brown University, Providence, R. I. 1912

Crouch, C. H., Professor of Mechanical Engineering and Director of Shops, University of North Dakota, Grand Forks, N. D..... 1907

Crow, Ray, 603 W. Camanche St., Norman, Okla.	1913
Crum, R. W., Associate Professor of Experimental Engineering, Iowa State College, Ames, Ia.	1912
Cullimore, A. R., Professor of Civil Engineering and Dean of Engineering, Delaware College, Newark, Del.	1914
Cummings, Harold N., Instructor in Practical Mathematics, Wentworth Institute, Boston, Mass.	1918
Curtis, L. F., Assistant Professor of Electrical Engineering, University of Washington, Seattle, Wash.	1913
Dadourian, H. M., Instructor in Physics, Yale University, New Haven, Conn.	1913
Daggett, P. H., Professor of Electrical Engineering, University of North Carolina, Chapel Hill, N. C.	1910
Dalaker, H. H., Assistant Professor of Mathematics, in Engineering College, University of Minnesota, Minneapolis, Minn.	1909
Dalburg, F. A., Superintendent, Arctic Coal Co., Advent Bay, Spitsburgen, Pa.	1908
Damon, George A., Consulting Engineer, 832 San Fernando Bldg., Los Angeles	1911
Danforth, R. H., Professor of Mechanics and Hydraulics, Case School of Applied Science, Cleveland, O.	1914
Daniels, Joseph, Associate Professor of Mining Engineering and Metallurgy, University of Washington, Seattle, Wash.	1910
Dargan, F. T., Professor of Electrical Engineering, Clemson A. & M. College of South Carolina, Clemson College, S. C.	1912
Dates, H. B., Professor of Electrical Engineering, Case School of Applied Science, Cleveland, O.	1904
Davidson, J. B., Professor of Agricultural Engineering, University of California, University Farm, Davis, Cal.	1915
Davidson, M. W., Professor of Mechanical Engineering, University of South Dakota, Vermilion, S. D.	1917
Davis, E. S., Instructor in Shop Practice, University of Oklahoma, Norman, Okla.	1917
Davis, Geo. Jacob, Jr., Dean and Professor of Civil Engineering, University of Alabama, University, Ala.	1913
Davis, Jas. C., Assistant Professor of Mechanical Drawing, Worcester Polytechnic Institute, Worcester, Mass.	1909
Davis, John C., Dean of the College of Applied Science and Engineering, Marquette University, Milwaukee, Wis.	1908
Davis, R. E., Instructor in Civil Engineering, University of Illinois, Urbana, Ill.	1913
Davis, R. P., Professor of Structural and Hydraulic Engineering, West Virginia University, Morgantown, W. Va.	1912

DAWES, C. L., Instructor in Electrical Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass. 1915

DAY, CHARLES, President, Day & Zimmerman, Inc., Engineers, 611 Chestnut St., Philadelphia, Pa. 1911

DEAN, STANLEY, Assistant Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill. 1917

DEARBORN, C. S., Mechanical Engineer, Blythe, Calif. 1910

DEARBORN, R. H., Head, Dept. of Electrical Engineering, Oregon Agricultural College, Corvallis, Ore. 1917

DEFOE, L. M., Professor of Mechanics, University of Missouri, Columbia, Mo. 1904

DEIMEL, R. F., Assistant Professor of Mechanics, Stevens Institute of Technology, Hoboken, N. J. 1909

DELAY, FREDERIC A., Head Instructor, Chicago Central Station Institute, 72 W. Adams St., Chicago Ill. 1909

DELONG, IRA M., Professor of Mathematics, University of Colorado, Boulder, Colo. 1917

DEMOREST, D. J., Professor of Metallurgy, The Ohio State University, Columbus, O. 1913

DENN, H. H., Instructor in Drawing, Germantown High School, Philadelphia, Pa. 1914

DENNISON, B. C., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1912

DENNY, GEO. H., President, University of Alabama, University, Ala. 1913

DENT, J. A., Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. 1911

DENTON, F. W., Consulting Engineer, Copper Range Co., 82 Devonshire St., Boston, Mass. 1894

DEPUY, C. E., Professor of Mechanical Engineering, Lewis Institute, Chicago, Ill. 1908

DERLETH, CHAS., JR., Professor of Civil Engineering and Dean of the College of Civil Engineering, University of California, Berkeley, Calif. 1904

DESCHWEINITZ, P. B., Professor of Machine Design, Lehigh University, Bethlehem, Pa. 1912

DETURK, J. A., Instructor in Machine Shop Practice, University of Illinois, Urbana, Ill. 1915

DIBERT, H. M., Civil Engineer with W. & L. E. Gurley, Troy, N. Y. 1913

DICKERSON, H. S., Professor of Mechanical Engineering, University of Missouri, School of Mines and Metallurgy, Rolla, Mo. 1912

DICKINSON, L. P., Professor of Physics and Electrical Engineering, Rhode Island State College, Kingston, R. I. 1914

Diederichs, Herman, Professor of Experimental Engineering, Cornell University, Ithaca, N. Y. 1915

Diemer, Hugo, Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. 1902

Dietz, J. W., Educational Director, Western Electric Co. Inc., Hawthorne Station, Chicago, Ill. 1911

Dix, L. E., Professor of Hydraulics and Sanitary Engineering, Norwich University, Northfield, Vt. 1917

Dobbs, F. E., Instructor in Estimating and Practical Mathematics, Wentworth Institute, Boston, Mass. 1912

Doggett, L. A., Professor of Electrical Engineering, U. S. Naval Academy, Annapolis, Md. 1914

Doherty, H. L., President, Cities Service Company, 60 Wall St., New York, N. Y. 1904

Doland, J. J., 3132 W. 22d Ave., Denver, Colo. 1914

Domonoske, Arthur B., 1172 C St., Hayward, Cal. 1913

Dooley, C. R., Manager, Educational Dept., Westinghouse Electric and Mfg. Co., and President of the Casino Technical Night School, East Pittsburgh, Pa. 1907

Dorroh, J. H., Dean, School of Engineering, Professor of Civil Engineering, University of Mississippi, University, Miss. 1917

Dorsey, J. W., Assistant Professor of Electrical Engineering, University of Manitoba, Winnipeg, Man. 1909

Dougherty, H. R., Professor and Head of Department of Mathematics, New York Military Academy, Cornwall-on-Hudson, N. Y. 1915

Dougherty, N. W., Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. 1914

Douglas, J. F. H., Assistant Professor of Physics, Texas A. & M. College, College Station, Tex. 1910

Dowell, Dawson, Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1917

Draffin, Jasper O., Instructor in Mechanics, The Ohio State University, Columbus, O. 1917

Dreyer, C. F., Head of the Department of Mechanical Engineering, Escola de Engenharia, Porto Alegre, Brazil 1913

Drinker, H. S., President, Lehigh University, South Bethlehem, Pa. 1905

Drowne, H. B., Engineer, Lane Construction Corporation, Meriden, Conn. 1908

Ducey, E. J., Draftsman, Lecturer on Structural Design, Fort Pitt Bridge Works, Canonsburg, Pa. 1915

Duff, C. M., Hallsville, Mo. 1912

Duffey, C. F., Professor of Science, University of Porto Rico, Rio

Piedras, P. R. 1916

Dufour, F. O., Engineer, with Stone & Webster, 147 Milk St., Boston, Mass. 1906

Dukes, R. G., Professor of Applied Mechanics, Purdue University, LaFayette, Ind. 1907

Duncan, M. M., Vice-President and General Manager, Cleveland Cliffs Iron Co., and Member Board of Control, Michigan College of Mines, Ishpeming, Mich. 1905

Dunham, Heber, Assistant Professor of Engineering Drawing, New York University, New York, N. Y. 1914

Dunkin, W. V., Chief Draftsman, Experimental Department, Deere & Co., 1656 30th Ave., Moline, Ill. 1908

Dunlap, J. H., Associate Professor of Hydraulics and Sanitary Engineering, State University of Iowa, Iowa City, Ia. 1916

Dunmore, G. B., Professor of Drafting, Whitman College, Walla Walla, Wash. 1911

Dunn, Gano, President, J. G. White Engineering Corporation, 43 Exchange Place, New York, N. Y. 1911

Dunn, Harold, Research Associate in Railway Engineering, Engineering Experiment Station, University of Ilinois, Urbana, Ill. 1917

Dunstan, E. V., Professor of Civil Engineering, George Washington University, Washington, D. C. 1909

duPont, T. C., Wilmington, Del. (Life Member) 1910

Durand, W. F., Professor of Mechanical Engineering, Leland Stanford Junior University, Stanford University, Calif. 1899

Durst, Ross C., Instructor in Civil Engineering, Municipal University of Akron, Akron, O. 1918

Dwight, H. B., Assistant Professor of Electrical Engineering, University of Colorado, Boulder, Colo. 1912

Dyche, H. E., Associate Professor of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

Dyer, F. C., Lecturer in Mining Engineering, Faculty of Applied Science, University of Toronto, Toronto, Ont., Canada 1913

Dysart, P. M., Physics Dept., Schenley High School, Pittsburgh, Pa. 1911

Earle, S. B., Director of the Engineering Department, and Professor of Mechanical Engineering, Clemson Agricultural College of South Carolina, Clemson College, S. C. 1912

Easby, Wm., Jr., Professor of Municipal Engineering, University of Pennsylvania, Philadelphia, Pa. 1908

Eaton, J. S., Instructor in Mechanical Practice, University of Vermont, Burlington, Vt. 1914

Ebaugh, W. C., Consulting Chemist, 809 Kearns Bldg., Salt Lake City, Utah 1908

ECKEL, C. L., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. 1914

ECKHARD, G. F., Professor of Structural Engineering, University of Vermont, Burlington, Vt. 1910

EDDISON, W. BARTON, Chief Engineer, Surface Combustion Co., New York, N. Y. 1914

EDDY, C. L., Assistant Professor of Railway Engineering, Case School of Applied Science, Cleveland, O. 1910

EDDY, H. T., Dean of the Graduate School and Professor of Mathematics and Mechanics, Emeritus, College of Engineering, University of Minnesota, Minneapolis, Minn. 1893

EDGECOMB, R. E., Instructor in Civil Engineering, University of Pennsylvania, Philadelphia, Pa. 1912

EDMANDS, S. S., Director, School of Science and Technology, Pratt Institute, Brooklyn, N. Y. 1903

EDMONDSON, T. W., Professor of Mathematics, New York University, University Heights, New York, N. Y. 1917

EDWARDS, WM. M., Professor of Civil and Municipal Engineering, University of Alberta, Edmonton South, Alberta, Canada 1914

EDWARDS, W. W., Head of Dept. of Applied Mechanics, Wentworth Institute, Boston, Mass. 1913

EHLERS, H. E., Assistant Chief, Bureau of Engineering, Public Service Commission, Harrisburg, Pa. 1912

ELDRED, C. P., Professor of Electrical Engineering, Head of Dept., Georgia School of Technology, Atlanta, Ga. 1918

ELL, CARL S., Dean, Coöperative Engineering School, Northeastern College, Boston, Mass. 1917

ELLER, WILLARD H., Assistant in Electrical Engineering, University of Idaho, Moscow, Ida. 1917

ELLIOTT, B. G., Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. 1912

ELLIS, C. A., Professor of Structural Engineering, University of Illinois, Urbana, Ill. 1916

ELLIS, FREDERICK, Instructor in Wood Working, Technical High School, Edmonton, Alberta, Canada.................................... 1912

ELLIS, W. T., Associate Professor of Machine Design and Applied Mechanics, North Carolina College of A. and M. Arts, West Raleigh, N. C. 1910

ELY, JOHN A., Professor of Surveying and Engineering, St. Johns University, Shanghai, China 1914

EMERSON, WM. H., Dean and Professor of Chemistry, Georgia School of Technology, Atlanta, Ga. 1912

EMORY, F. L., Professor of Mechanics and Applied Mathematics, West Virginia University, Morgantown, W. Va. 1894

EMRICK, PAUL S., Instructor in Electrical Engineering, Purdue University, LaFayette, Ind. 1914

EMSWILER, J. E., Associate Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1912

ENDSLEY, L. E., Professor of Railway Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1907

ENGEL, GODFREY, Engineer of Construction, American Sugar Refining Co. of New York, Brooklyn, N. Y. 1915

ENGER, M. L., Associate Professor of Mechanics and Hydraulics, University of Illinois, Urbana, Ill. 1907

ENNIS, W. D., Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1907

ENO, F. H., Professor of Municipal Engineering, The Ohio State University, Columbus, O. 1907

ENSIGN, N. E., Associate in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1915

ESTY, WILLIAM, Professor of Electrical Engineering, Lehigh University, South Bethlehem, Pa. 1898

EVANS, F. H., Dean, College of Industrial Science, Toledo University, Toledo, O. 1907

EVANS, H. B., Professor of Mathematics, University of Pennsylvania, Philadelphia, Pa. 1908

EVANS, H. S., Professor of Electrical Engineering, University of Colorado, Boulder, Colo. 1905

EWING, D. D., Associate Professor of Electrical Railway Engineering, Purdue University, LaFayette, Ind. 1910

EYRE, T. T., Assistant Professor of Mechanical Engineering, Purdue University, LaFayette, Ind. 1909

FAIG, J. T., Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, O. 1899

FARNHAM, C. S., Assistant Professor of Civil Engineering, Yale University, New Haven, Conn. 1908

FARWELL, S. P., Chief, Service Division, State Public Utilities Commission of Illinois, Springfield, Ill. 1911

FELGAR, JAS. H., Dean of the College of Engineering, University of Oklahoma, Norman, Okla. 1912

FERGUSON, O. J., Acting Dean, Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1908

FERMIER, E. J., Professor of Mechanical Engineering, Texas A. and M. College, College Station, Texas 1903

FERNALD, R. H., Whitney Professor of Dynamical Engineering, University of Pennsylvania, Philadelphia, Pa. 1899

Ferris, Charles E., Professor of Mechanical Engineering and Dean of Engineering, University of Tennessee, Knoxville, Tenn. 1913

Fessenden, E. A., Professor of Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1912

Fetter, Frank A., Professor of Economics, Princeton University, Princeton, N. J. 1915

Finch, F. R., Assistant Professor of Descriptive Geometry and Drawing, University of Michigan, Ann Arbor, Mich. 1913

Fine, H. B., Professor of Mathematics and Dean of the Departments of Science, Princeton University, Princeton, N. J. 1909

Fish, E. H., New England Associate Editor, *American Machinist*, Worcester, Mass. 1912

Fish, F. A., Professor of Electrical Engineering, Iowa State College, Ames, Ia. 1905

Fisher, Geo. H., Statistician, International Textbook Company, Scranton, Pa. 1911

Fisher, James, Professor of Mathematics and Physics, Michigan College of Mines, Houghton, Mich. 1899

Fisk, Ira W., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1914

Fisk, Wilbur C., President, Hudson & Manhattan R. R., (Hudson River Tunnels), 30 Church St., New York, N. Y. 1914

Fitterer, J. C., Professor of Civil and Irrigation Engineering, University of Wyoming, Laramie, Wyo. 1912

FitzGerald, Desmond, Consulting Engineer, 410 Washington St., Brookline, Mass. 1911

Flather, J. J., Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1893

Fleming, V. R., Assistant Professor of Applied Mechanics, University of Illinois, Urbana, Ill. 1909

Fletcher, A. B., Highway Engineer, Dept. of Engineering, State of California, Sacramento, Calif. 1913

Fletcher, Robert, Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. 1894

Flowers, A. E., Professor of Electrical Engineering, The Ohio State University, Columbus, O. 1910

Focke, T. M., Kerr Professor of Mathematics, Case School of Applied Science, Cleveland, O. 1907

Fogg, R. J., Associate Professor of Civil Engineering, Lehigh University, South Bethlehem, Pa. 1910

Folk, J. Thomas, Instructor in Mechanical Engineering Department, Louisiana Industrial Institute, Ruston, La. 1914

FOLWELL, A. P., Managing Editor, *Municipal Journal*, Montclair, N. J.	1916
FOLTZ, LEROY S., Assistant Professor of Electrical Engineering, Colorado Agricultural College, Ft. Collins, Colo.	1918
FOOTE, F. S., JR., Professor of Railroad Engineering, University of California, Berkeley, Calif.	1910
FORAKER, F. A., Assistant Professor of Mathematics, University of Pittsburgh, Pittsburgh, Pa.	1914
FORD, ARTHUR H., Professor of Electrical Engineering, State University of Iowa, Iowa City, Ia.	**1903**
FORD, H. C., Associate Professor of Civil Engineering, Iowa State College, Ames, Ia.	**1907**
FORMAN, A. H., Professor of Electrical Engineering, West Virginia University, Morgantown, W. Va.	1916
FOSS, F. E., Professor of Civil Engineering, Cooper Union, New York, N. Y.	**1893**
FOSS, MARTIN M., Secretary, McGraw-Hill Book Co., Inc., 239 W. 39th St., New York, N. Y.	1909
FOSTER, E. S., with the Packard Electric Co., Warren, Ohio	1911
FOULK, C. W., Professor of Analytical Chemistry, The Ohio State University, Columbus, O.	1913
FRANK, E. D. A., Mechanical Engineer, Marine Dept., C. H. Wheeler Mfg. Co., Philadelphia, Pa.	1917
FRANKFORTER, G. B., Professor of Chemistry and Dean of the School of Chemistry, University of Minnesota, Minneapolis, Minn.	**1897**
FRANKLIN, WILLIAM S., Massachusetts Institute of Technology, Cambridge, Mass.	1900
FRAZER, JOHN, Dean of the Towne Scientific School and Assistant Professor of Chemistry, University of Pennsylvania, Philadelphia, Pa.	1914
FRAZIER, F. F., Assistant Professor of Civil Engineering, Kansas State Agricultural College, Manhattan, Kans.	1912
FREAR, J. B., Instructor in Engineering Mechanics and Mathematics, University of Minnesota, Minneapolis, Minn.	1911
FREEDMAN, W. H., Professor of Electrical Engineering, University of Vermont, Burlington, Vt.	**1902**
FREEMAN, E. H., Professor of Electrical Engineering, Armour Institute of Technology, Chicago, Ill.	**1909**
FREEMAN, P. J., Engineer of Tests, Pittsburgh Testing Laboratory, Pittsburgh, Pa.	1914
FREEMAN, W. EDWIN, Professor of Electrical Engineering, University of Kentucky, Lexington, Ky.	1911

French, A. W., Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1900

French, Thos. E., Professor of Engineering Drawing, The Ohio State University, Columbus, O. 1899

Frink, F. G., Private Practice, Palo Alto, Calif. 1902

Frost, Harwood, President, Brown Portable Conveying Machinery Co., Room 840, 10 S. LaSalle St., Chicago, Ill. 1907

Fry, H. P., Assistant Professor of Mechanical Drawing, Mechanical Engineering Department, University of Pennsylvania, Philadelphia, Pa. 1914

Fry, Lawford, H., General Inspector, Standard Steel Works Co., Burnham, Pa. 1911

Fullan, M. T., Professor of Machine Design and Drawing, Alabama Polytechnic Institute, Auburn, Ala. 1915

Fuller, A. H., Professor of Civil Engineering, Lafayette College, Easton, Pa. 1901

Fuller, C. E., Professor of Theoretical and Applied Mechanics, Massachusetts Institute of Technology, Cambridge, Mass. 1907

Fulton, Wm. L., Assistant Professor of Mathematics and Civil Engineering, University of Vermont, Burlington, Vt. 1912

Furman, Franklin DeR., Professor of Mechanism and Machine Design, Stevens Institute of Technology, Hoboken, N. J. 1907

Furr, M. W., Instructor in Civil and Highway Engineering, Kansas State Agricultural College, Manhattan, Kans. 1917

Galpin, S. L., Assistant Professor of Geology and Mining, Iowa State College, Ames, Ia. 1915

Garman, H. O., Chief Engineer of the Indiana Public Utilities Commission, 2062 N. Meridian St., Indianapolis, Ind. 1907

Garrett, L. E., Associate Professor of Mathematics, University of Missouri, School of Mines and Metallurgy, Rolla, Mo. 1910

Garver, J. D., Assistant Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1915

Garver, N. B., Associate in Civil Engineering, University of Illinois, Urbana, Ill. 1910

Gates, A. O., Sales Engineer, Dodge Sales & Engineering Co., 814 Newhouse Bldg., Salt Lake City, Utah 1914

Gay, R. W., Professor of Civil Engineering, Mississippi A. and M. College, Agricultural College, Miss. 1907

Gearhart, W. S., State Highway Engineer, Topeka, Kans. 1915

George, R. D., Professor of Geology and State Geologist of Colorado, University of Colorado, Boulder, Colo. 1914

George, S. G., Professor of Mechanics of Engineering, College of Civil Engineering, Cornell University, Ithaca, N. Y. 1914

Gibson, A. J., Professor of Engineering, University of Queensland, Brisbane, Queensland, Australia 1910

Gibson, J. L., Dean of School of Arts and Sciences, Professor of Mathematics, University of Utah, Salt Lake City, Utah 1911

Giesecke, F. E., Professor of Architecture, University of Texas, Austin, Tex. 1893

Gilbreth, F. B., President, F. B. Gilbreth, Inc., 77 Brown St., Providence, R. I. 1911

Gilchrist, J. F., Vice President, Commonwealth Edison Co., Chicago, Ill. 1911

Gillespie, **Peter**, Associate Professor of Applied Mechanics, University of Toronto, Toronto, Ontario 1905

Gillette, H. P., Editor in Chief, *Engineering & Contracting*, 608 S. Dearborn St., Chicago, Ill. 1905

Gilmore, L. H., Professor of Physics, Throop College of Technology, Pasadena, Calif. 1912

Gladson, W. N., Vice President, Dean, College of Engineering, University of Arkansas, Fayetteville, Ark. 1903

Goddard, A. L., Supt. of Shops and Assistant Professor of Mechanical Practice, University of Wisconsin, Madison, Wis. 1912

Goddard, R. W., Professor of Electrical Engineering, New Mexico College of A. & M. Arts, State College, N. Mex. 1915

Godfrey, **Hollis**, President, Drexel Institute; Commissioner, Advisory Commission of the Council of National Defense, Philadelphia, Pa. 1913

Goldingham, A. H., Sales Engineer, De la Vergne Machine Co., New York, N. Y. 1911

Goodenough, G. A., Professor of Thermodynamics, University of Illinois, Urbana, Ill. 1900

Goss, W. F. M., President, Railway Car Manufacturers Association, 61 Broadway, New York, N. Y. 1893

Gould, F. A., City Engineer, Owosso, Mich. 1916

Goulding, **Herbert**, J., Associate Professor of Descriptive Geometry and Drawing, University of Michigan, Ann Arbor, Mich. 1914

Graham, P. H., Professor of Physics and Astronomy, Agnes Scott College, Decatur, Ga. 1916

Graham, **Wm. P.**, Professor of Electrical Engineering and Dean of the College of Applied Science, Syracuse University, Syracuse, N. Y. 1912

Gram, L. M., Professor of Structural Engineering, University of Michigan, Ann Arbor, Mich. 1913

Grant, E. D., Associate Professor of Mathematics and Physics, Michigan College of Mines, Houghton, Mich. 1905

Gray, Alexander, Professor in charge of Electrical Engineering Department, Cornell University, Ithaca, N. Y. 1915

Green, Chas. W., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. ... 1912

Green, R. M., Assistant Professor of Highway Engineering, A. & M. College of Texas, College Station, Tex. 1916

Greene, A. M., Jr., Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1903

Greenough, Maurice B., Instructor in Civil Engineering, Case School of Applied Science, Cleveland, Ohio.................. 1912

Gregory, W. B., Professor of Experimental Engineering, Tulane University; Irrigation Engineer, U. S. Department of Agriculture, New Orleans, La. 1907

Greiner, J. E., Consulting Engineer, Fidelity Bldg., Baltimore, Md. 1911

Greve, F. W., Jr., Assistant Professor of Hydraulic Engineering, Purdue University, LaFayette, Ind. 1912

Griswold, Robt. G., Chief Technologist, H. L. Doherty & Company, 60 Wall St., New York, N. Y. 1917

Groat, B. F., Hydraulic Engineer, 2400 Oliver Bldg., Pittsburgh, Pa. 1899

Groetzinger, Carl A., Instructor in Descriptive Geometry, Case School of Applied Science, Cleveland, O. 1917

Grondahl, L. O., Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. 1915

Grover, N. C., Chief Hydraulic Engineer, United States Geological Survey, Washington, D. C. 1894

Grumbein, J. B., Professor of Steam and Experimental Engineering, West Virginia University, Morgantown, W. Va. 1912

Grundhoeffer, E. F., The Pennsylvania State College, State College, Pa. 1915

Gummere, H. V., Director of Evening Courses and Professor of Mathematics, Drexel Institute, Philadelphia, Pa. 1914

Gunther, Chas. O., Professor of Mathematics, Stevens Institute of Technology, Hoboken, N. J. 1907

Gwiazdowski, A. S., Associate Professor of Mechanical Engineering, Toledo University, Toledo, O. 1917

Hagerty, C. T., Professor of Mathematics and Astronomy, New Mexico College of A. & M. Arts, State College, New Mexico.. 1911

Haigler, Chas. E., Professor of Mathematics, Wentworth Institute, Boston, Mass. 1912

Hale, R. S., Supt., Special Research Dept. Edison Illuminating Company of Boston, Boston, Mass. 1916

Hall, Arthur A., Associate Professor of Applied Electricity, West Virginia University, Morgantown, W. Va. 1918

Hall, James A., Assistant Professor of Mechanical Engineering, Brown University, Providence, R. I. 1914

Hall, P. R., Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912

Hall, W. H., Assistant Professor of Engineering, Trinity College, Durham, N. C. 1917

Hallock, J. W., Director, Co-operative Work, University of Pittsburgh, Pittsburgh, Pa. 1915

Hallsted, J. C., Engineer, Robert W. Hunt Co., Chicago, Ill. 1910

Halsey, F. A., Commissioner, American Institute of Weights and Measures, New York, N. Y. 1907

Halsey, W. D., Instructor in Mechanical Engineering, George Washington University, Washington, D. C. 1917

Ham, Wm. R., Professor of Physics, Pennsylvania State College, State College, Pa. 1914

Hamerschlag, A. A., President, Carnegie Institute of Technology, Pittsburgh, Pa. 1903

Hamilton, Edw. P., Secretary, John Wiley & Sons., Inc., 432 Fourth Ave., New York, N. Y. 1914

Hamilton, Geo. A., 532 Morris Ave., Elizabeth, N. J. 1911

Hamilton, J. McC., President, Montana State College of A. & M. Arts, Bozeman, Mont. 1912

Hamilton, J. O., Professor of Physics, Kansas State Agricultural College, Manhattan, Kans. 1910

Hamlin, Hannibal L., Division Head, Boston Industrial School for Boys, Boston, Mass. 1912

Hammer, M. R., Associate Professor of Drawing, Northwestern University, Evanston, Ill. 1917

Hammond, H. P., Assistant Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1916

Hancock, Charles, Professor of Mechanical Engineering, University of Virginia, University, Va. 1915

Haney, J. W., Instructor in Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1916

Hanna, U. S., Associate Professor of Mathematics, Indiana University, Bloomington, Ind. 1915

Harding, C. F., Professor of Electrical Engineering and Director of the Electrical Laboratories, Purdue University, LaFayette, Ind. 1908

Haring, Alexander, Professor of Bridge and Railway Engineering, New York University, New York, N. Y. 1907

Harper, A. C., Associate in Machine Design, University of Illinois, Urbana, Ill. 1911

HARPER, C. H., Instructor in Drawing and Mathematics, Chestnut Hill Academy, Chestnut Hill, Philadelphia, Pa. 1909
HARRINGTON, J. L., Consulting Engineer, Harrington, Howard & Ash, Kansas City, Mo. 1903
HARRIS, C. L., Assistant Professor of Architectural Engineering, The Pennsylvania State College, State College, Pa. 1914
HARRIS, F. C., Instructor in Architecture and Drawing, Kansas State Agricultural College, Manhattan, Kans. 1910
HARRIS, L. H., Professor and Head of the Department of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1912
HARRIS, WALTER B., Professor of Geodesy, Princeton University, Princeton, N. J. 1914
HARTER, G. A., Professor of Mathematics and Physics, Delaware College, Newark, Del. 1908
HARTMANN, F. M., Professor of Electrical and Mechanical Engineering, Cooper Union, New York, N. Y. 1908
HARVEY, J. W., Assistant Professor of Electrical Engineering, University of Maine, Orono, Me. 1916
HASEMAN, CHARLES, Professor of Mathematics and Mechanics, University of Nevada, Reno, Nev. 1914
HASKELL, E. E., Dean of the College of Civil Engineering, Cornell University, Ithaca, N. Y. 1907
HASKELL, F. E., Assistant Examiner, U. S. Patent Office, Washington, D. C. 1914
HASKELL, M. W., Professor of Mathematics, University of California, Berkeley, Cal. 1910
HASTINGS, H. B., Professor of Applied Economics, Reed College, Portland, Ore. 1908
HATJIDAKIS, GEORGE, Piraeus, Greece 1913
HATT, W. K., Professor of Civil Engineering and Director of the Materials Testing Laboratory, Purdue University, LaFayette, Ind. 1895
HAUSMANN, ERICH, Associate Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1914
HAVENS, WM. W., Civil Engineer, 2453 Valentine Ave., New York, N. Y. 1914
HAVILAND, EDWIN, With the Seattle Lighting Co., Seattle, Wash. . 1902
HAWES, J. H., Junior Master, Dorchester High School, Dorchester Center, Mass. 1900
HAWLEY, J. B., Consulting Engineer, F. and M. Bank Bldg., Ft. Worth, Tex. 1911
HAY, E. D., Professor of Drawing and Machine Design, Oshkosh Normal School, Oshkosh, Wis. 1915

Hayes, Thornton, 7224 Idlewild St., Pittsburgh, Pa. 1915

Hayford, J. F., Director of the College of Engineering, Northwestern University, Evanston, Ill. 1905

Hayward, H. W., Associate Professor of Applied Mechanics, Massachusetts Institute of Technology, Cambridge, Mass. 1904

Hazeltine, L. A., Acting Professor of Electrical Engineering, Stevens Institute of Technology, Hoboken, N. J. 1910

Heck, Robert C. H., Professor of Mechanical Engineering, Rutgers College, New Brunswick, N. J. 1907

Hedrick, E. R., Professor of Mathematics, University of Missouri, Columbia, Mo. 1910

Hedrick, I. G., Senior Member of Hedrick & Hedrick, Consulting Engineers, 506 Inter State Bldg., Kansas City, Mo. 1903

Hedrick, Wm. A., Head of the Department of Physics of the High and Manual Training Schools, Central High School, Washington, D. C. 1913

Helman, M. P., Instructor in Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1914

Hendry, W. S., Instructor in Mechanic Arts, University of Arizona, Tucson, Ariz. 1915

Henley, W. W., Professor of Mechanic Arts, University of Arizona, Tucson, Ariz. 1907

Henshall, P. P., Instructor in Machine Shop, Pennsylvania State College, State College, Pa. 1915

Herget, A. M., Professor of Drawing and Mechanic Arts, Louisiana State University, Baton Rouge, La. 1903

Hering, Rudolph, Hydraulic and Sanitary Consulting Engineer, 170 Broadway, New York, N. Y. 1911

Herschel, W. H., Assistant Physicist, Bureau of Standards, Washington, D. C. 1911

Herty, C. H., Editor, *Journal of Industrial and Engineering Chemistry*, 35 East 41st St., New York, N. Y. 1912

Hesse, G. Ernest, Text Book Publisher, 26 Rollins Place, Yonkers, N. Y. 1914

Hewerdine, T. S., Civil Engineer, Olivia, Minn. 1907

Hewitt, C. E., Dean of Engineering, New Hampshire College of A. & M. Arts, Durham, N. H. 1915

Hibbard, H. Wade, Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. 1896

Hickerson, T. F., Associate Professor of Civil Engineering, University of North Carolina, Chapel Hill, N. C. 1914

Higbee, F. G., Professor and Head of the Department of Descriptive Geometry and Drawing, State University of Iowa, Iowa City, Ia. 1906

Higbie, H. H., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1908

Higgins, Chas. H., Consulting Engineer; Secretary Princeton Engineering Association, 30 Church St., New York, N. Y. 1912

Hill, Clifton R., Assistant Professor of Civil Engineering, University of Nevada, Reno, Nev. 1918

Hill, J. E., Professor of Civil Engineering, Brown University, Providence, R. I. 1894

Hill, Wm. W., Professor of Electrical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1912

Hillebrand, W. A., 345 Kellog Ave., Palo Alto, Calif. 1910

Hillegass, H. H., Assistant Professor of Electrical Engineering, University of Maine, Orono, Me. 1916

Hiroi, Isami, Professor of Civil Engineering, Tokyo Imperial University, College of Engineering, Tokyo, Japan.............. 1910

Hitchcock, F. A., Professor of Civil Engineering, New Mexico State College of A. & M., State College, N. Mex. 1913

Hitchcock, Geo. G., Professor of Physics, Pomona College, Claremont, Calif. 1911

Hitchcock, G. P., Vice-Chairman of Faculty and Assistant to the Secretary, Pratt Institute, Brooklyn, N. Y................ 1914

Hitchcock, W. A., Assistant Professor of Civil Engineering, University of Wyoming, Laramie, Wyo. 1915

Hixon, C. R., Assistant Professor of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1910

Hoad, W. C., Professor of Sanitary Engineering, University of Michigan, Ann Arbor, Mich. 1907

Hodgkins, H. L., Dean of the College of Engineering and Professor of Mathematics, George Washington University, Washington, D. C. 1908

Hodson, L. C., Associate Professor of Mining Engineering, Iowa State College, Ames, Ia. 1915

Hoefer, E. G., Professor of Mechanical and Electrical Engineering, University of Wyoming, Laramie, Wyo. 1910

Hoerning, Carlos, Professor of Mechanical Engineering, Universidad de Chile, Santiago, Chile. 1912

Hoexter, S. J., with Esselstyn-Murphy Co., Engineers, 206 Telegraph Bldg. Detroit, Mich. 1914

Hofmann, G. A., Professor of Mechanical Engineering, St. Mary College, Dayton, O. 1916

Hofman, H. O., Professor of Metallurgy, Massachusetts Institute of Technology and Harvard University, Cambridge, Mass. ... 1894

Hoffman, A. H., Head, Dept. of Agricultural Engineering, New Mexico State College, State College, N. M. 1907

HOFFMAN, J. D., Head, Dept. of Practical Mechanics; Professor of Practical Mechanics; Director, Laboratories of Practical Mechanics, Purdue University, LaFayette, Ind. 1907

HOGG, WM. T., Instructor in Civil Engineering, The Tulane University, New Orleans, La. 1914

HOLBROOK, E. A., Supervising Mining Engineer and Metallurgist, U. S. Bureau of Mines, Urbana, Ill. 1912

HOLDEN, C. A., Professor of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H.......... 1901

HOLDER, F. J., Professor of Mathematics, University of Pittsburgh, Pittsburgh, Pa. 1912

HOLLIS, I. N., President, Worcester Polytechnic Institute, Worcester, Mass. 1894

HOLLISTER, S. C., Research Engineer, Corrugated Bar Company, Buffalo, N. Y. 1916

HOLLISTER, V. L., Associate Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1911

HOLMAN, W. F., Assistant Professor of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1912

HOLMES, PAUL E., Assistant Instructor, Kansas State Agricultural College, Manhattan, Kans. 1917

HOOD, GEO. J., Professor of Engineering Drawing, University of Kansas, Lawrence, Kans. 1914

HOOD, O. P., Chief Mechanical Engineer, U. S. Bureau of Mines, In charge Pittsburgh Station, Pittsburgh, Pa. 1893

HOOPER, E. G., Assistant Engineer, Dept. Water Supply, Gas and Electricity, 417 East 236th St., New York, N. Y. 1909

HOOPER, W. L., Professor of Electrical Engineering, Tufts College, Tufts College, Mass. 1907

HOSKINS, L. M., Professor of Applied Mathematics, 365 Lincoln Ave., Palo Alto, Calif. 1893

HOSMER, GEO. L., Associate Professor of Topographical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1914

HOTCHKISS, HOMER J., Instructor in Mechanics of Engineering, Cornell University, Ithaca, N. Y. 1914

HOUGHTON, C. E., Professor of Mechanics, New York University, New York, N. Y. 1908

HOUSE, E. B., Professor of Civil and Irrigation Engineering, Colorado State Agricultural College, Ft. Collins, Colo. 1913

HOUSTON, HALE, Professor of Civil Engineering, Clemson A. & M. College, Clemson College, S. C. 1914

HOWARD, J. W., Assistant Professor of Topographical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1907

Howe, C. D., Chief Engineer, Grain Commission for Canada, Fort William, Ontario, Canada 1912

Howe, C. S., President of the Case School of Applied Science, Cleveland, O. 1902

Howe, Leon B., Professor of Drawing, College of Applied Science, Syracuse University, Syracuse, N. Y. 1917

Howe, M. A., Emeritus Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1894

Hower, H. S., Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. 1914

Hoxton, L. G., Professor of Physics, University of Virginia, University, Va. 1915

Hubbard, A. K., 2 Highland Park, Batavia, N. Y. 1907

Hudson, C. W., Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1909

Hughes, H. J., Professor of Civil Engineering, Harvard University, 1–337 Massachusetts Institute of Technology, Cambridge, Mass. 1907

Hume, Alfred, Vice-Chancellor, Dean, College of Liberal Arts, and Professor of Mathematics, University of Mississippi, University, Miss. 1894

Humphreys, A. C., President, Stevens Institute of Technology, Hoboken, N. J. 1903

Humphreys, D. C., Dean of the School of Applied Science and Professor of Civil Engineering, Washington and Lee University, Lexington, Va. 1893

Hund, August, Research Engineer, 2314 Channing Way, Berkeley, Calif. 1914

Hunt, Chas. Warren, Secretary, the American Society of Civil Engineers, 33 West 39th St., New York, N. Y. 1911

Hunt, Robert W., Senior Member of Robert Hunt & Co., Chicago, Ill. 1913

Hunter, J. A., Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. 1904

Huntington, E. V., Associate Professor of Mathematics, Harvard University, Cambridge, Mass. 1906

Huntington, W. C., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1914

Hutchins, R. E., Assistant Professor of Mechanics, State University of Iowa, Iowa City, Ia. 1912

Hyde, A. L., Associate Professor of Bridge Engineering, University of Missouri, Columbia, Mo. 1904

Hyde, E. P., Director, Nela Research Laboratory, National Lamp Works of General Electric Co., Nela Park, Cleveland, O. 1911

Ingram, E. L., Professor of Railroad Engineering and Geodesy, University of Pennsylvania, Philadelphia, Pa. 1908

Ives, F. W., Assistant Professor of Agricultural Engineering, The Ohio State University, Columbus, O. 1910

Ives, H. C., Professor of Railroad Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1901

Iyer, R. P., Supervisor, Public Works Department, Teruverambur P. O., Trechwofoltz District, Deccan, India.................. 1910

Jablow, Charles, Associate Professor of Mechanical Engineering, in charge of Department, Oklahoma A. & M. College, Stillwater, Okla. 1910

Jackson, Dugald C., Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass. 1893

Jackson, John Price, Commissioner, Dept. of Labor and Industry, Commonwealth of Pennsylvania, Harrisburg, Pa. 1894

Jacobus, D. S., Advisory Engineer, The Babcock & Wilcox Co., and Special Lecturer in Experimental Engineering, Stevens Institute of Technology, Hoboken, N. J. 1893

Jacoby, H. S., Professor of Bridge Engineering, Cornell University, 105 Harvard Place, Ithaca, N. Y. 1894

James, J. H., Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1910

James, R. L., Assistant Professor of Engineering Drawing, University of North Carolina, Chapel Hill, N. C. 1914

James, W. G., Associate Professor of Electrical Engineering, A. & M. College of Texas, College Station, Tex. 1917

Jameson, J. M., Vice President, Girard College, Philadelphia, Pa. 1903

Jenkins, D. R., Assistant Professor of Electrical Engineering, University of Colorado, Boulder, Colo. 1912

Jenson, Joseph, Consulting Engineer, Valury, Nev. 1903

Jewett, A. C., 410 Whalley Ave., New Haven, Conn. 1907

Jewett, F. B., Chief Engineer, Western Electric Co., 463 West St., New York, N. Y. 1914

Jobson, A. J., General Superintendent, Wyoming Electric Co., Casper, Wyo. 1910

Johnson, A. R., Assistant Professor of Mathematics and Graphics, Rutgers College, New Brunswick, N. J. 1909

Johnson, C. A., Oakmont, Pa. 1915

Johnson, E. A., Head of the Foundry Dept., Wentworth Institute, Boston, Mass. 1913

Johnson, F. Ellis, Assistant Professor of Electrical Engineering, University of Kansas, Lawrence, Kans. 1916

JOHNSON, L. J., Professor of Civil Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass.	1898
JOHNSON, PHELPS, President, Dominion Bridge Co.; President, St. Lawrence Bridge Co., Montreal, Canada	1910
JOHNSON, WM. F., Philadelphia Electric Co., Philadelphia, Pa.	1913
JOHNSTON, C. T., Professor of Geodesy and Surveying, University of Michigan, Ann Arbor, Mich.	1913
JOHNSTON, W. A., Professor of Theoretical and Applied Mechanics, Massachusetts Institute of Technology, Cambridge, Mass.	1907
JONES, BASSETT, JR., Consulting Engineer, 101 Park Ave., New York, N. Y.	1907
JONES, C. R., Dean of the College of Engineering and Professor of Steam and Experimental Engineering, West Virginia University, Morgantown, W. Va.	1895
JONES, E. C., Instructor in Shop Practice, Kansas State Agricultural College, Manhattan, Kans.	1917
JONES, F. E., Assistant Professor of Mechanic Arts, University of Kansas, Lawrence, Kans.	1915
JONES, F. R., Mechanical and Electrical Engineer, 1702 Melrose Place, Knoxville, Tenn.	1893
JONES, G. R., Associate Professor of Civil Engineering, The Johns Hopkins University, Baltimore, Md.	1914
JONES, J. O., Assistant Professor of Hydraulics, University of Kansas, Lawrence, Kans.	1916
JORDAN, H. H., Associate in General Engineering Drawing, University of Illinois, Urbana, Ill.	1915
JUDD, HORACE, Associate Professor of Experimental Engineering, Ohio State University, Columbus, O.	1907
KAMRASS, BENJAMIN, Assistant Engineer, Engineering Experiment Station, Iowa State College, Ames, Ia.	1917
KANE, S. M., Instructor in Metal Work and Chief Engineer, University of Washington, Seattle, Wash.	1918
KARAPETOFF, VLADIMIR, Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.	1909
KAVANAUGH, W. H., Professor of Experimental Engineering, University of Pennsylvania, Philadelphia, Pa.	1902
KAY, EDGAR B., Consulting Engineer, Tuscaloosa, Ala.	1898
KEELY, R. R., Consulting Engineer, 10 Palmer Ave., Plainfield, N. J.	1910
KEGERREIS, ROY, Graduate Student, Columbia University, New York, N. Y.	1913
KELLER, A. R., 2066 Lanihuli Drive, Honolulu, T. H.	1910
KELLER, J. O., Instructor in Industrial Engineering, The Pennsylvania State College, State College, Pa.	1916

Kelley, Howard G., President, Grand Trunk Railway System, Montreal, P. Q., Canada.	1910
Kellogg, E. W., Research Laboratory, General Electric Co., Schenectady, N. Y.	1913
Kenerson, W. H., Professor of Mechanical Engineering, Brown University, Providence, R. I.	1903
Kenison, Ervin, Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass.	1912
Kennedy, F. L., Associate Professor of Engineering Drawing, Harvard University, Cambridge, Mass.	1904
Kennelly, A. E., Professor of Electrical Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass.	1916
Kent, H. L., Principal, School of Agriculture, and Associate Professor of Education, Kansas State Agricultural College, Manhattan, Kans.	1915
Kent, J. M., Instructor in Steam and Electricity, Manual Training High School and Polytechnic Institute Night School, Kansas City, Mo.	1903
Kent, William, Consulting Engineer, 57 So. Fullerton Ave., Montclair, N. J.	1894
Keown, R. McA., Assistant Professor of Machine Design, University of Wisconsin, Madison, Wis.	1910
Kerr, E. W., Professor of Mechanical Engineering, Louisiana State University, Baton Rouge, La.	1910
Ketchum, Milo S., Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado, Boulder, Colo.	1903
Kidd, J. W., Professor of Engineering, Texas State School of Mines and Metallurgy, Fort Bliss, Tex.	1908
Kiefer, P. J., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa.	1917
Kimball, D. S., Professor of Machine Design and Industrial Engineering, Cornell University, Ithaca, N. Y.	1915
King, Carl, Instructor in Materials of Construction, Wentworth Institute, Boston, Mass.	1912
King, E. E., Professor of Railway Engineering, Iowa State College, Ames, Ia.	1908
King, H. W., Professor of Hydraulic Engineering, University of Michigan, Ann Arbor, Mich.	1913
King, R. S., Professor of Experimental Enginering, Georgia School of Technology, Atlanta, Ga.	1904
Kingsbury, Albert, Consulting Engineer, 219 Stratford Ave., Pittsburgh, Pa.	1893

Kinsey, A. S., Supervising Instructor in Shop Practice, Stevens Institute of Technology, Hoboken, N. J. 1912

Kinsley, Carl, Associate Professor of Physics, University of Chicago, Chicago, Ill. 1903

Kirby, R. S., Assistant Professor of Drawing and Descriptive Geometry, Sheffield Scientific School, Yale University, New Haven, Conn. 1911

Kirchner, W. H., Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1910

Kirkham, J. E., Professor of Structural Engineering, Iowa State College, Ames, Ia. 1915

Klein, A. W., Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa. 1908

Knapp, E. R., Professor of Descriptive Geometry and Mechanical Drawing, Stevens Institute of Technology, Hoboken, N. J..... 1912

Knapp, W. A., Assistant Professor of Structural Engineering, Purdue University, LaFayette, Ind. 1914

Kneale, R. D., Professor of Highway Engineering, Georgia School of Technology, Atlanta, Ga. 1912

Knight, C. D., Assistant Professor of Experimental Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1907

Knight, W. A., Associate Professor of Machine Shop Practice, Ohio State University, Columbus, O. 1907

Knoch, Julius J., Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. 1898

Knoettge, Carl H., Instructor in Civil Engineering, University of Colorado, Boulder, Col. 1918

Knowles, Morris, Director, Department of Sanitary Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

Koerber, G. A., Professor of Electrical Engineering, Delaware College, Newark, Del. 1915

Kondo, Sentaro, Civil Engineer, No. 27 Tatsuokacho Hongo, Tokyo, Japan 1911

Kondo, Toragoro, Chief of Technical Division, Public Works Bureau, Home Department, Tokyo, Japan (Life Member) .. 1911

Krewson, R. H., Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912

Krotzer, Fred. W., Instructor in Electricity, Central Continuation School, Y. M. C. A., Milwaukee, Wis. 1915

Krotzer, J. Earl, Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1918

Kunze, E. J., Professor of Mechanical Engineering, in charge of Department, Oklahoma A. & M. College, Stillwater, Okla. 1907

Lagergren, J. T., Lecturer in Machine Design, University of Toronto, Toronto, Ont., Canada. 1912
Lambert, B. J., Professor of Structural Engineering, State University of Iowa, Iowa City, Ia. 1907
Lambert, P. A., Professor of Mathematics, Lehigh University, South Bethlehem, Pa. 1897
Lambie, J. S., Associate Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914
Landreth, Olin H., Professor of Civil Engineering, Union University, Schenectady, N. Y. 1893
Langille, H. B., Assistant Professor of Machine Design and Mechanical Drawing, University of California, Berkeley, Cal. 1915
Langsdorf, A. S., Dean of the Schools of Engineering and Architecture and Professor of Electrical Engineering, Washington University, St. Louis, Mo. 1903
Lanier, A. C., Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1915
Lapham, J. R., Assistant Professor of Civil Engineering, George Washington University, Washington, D. C. 1912
Lapham, J. S., Adjunct Professor of Experimental Engineering, University of Virginia, University, Va. 1915
Larson, G. L., Associate Professor of Steam and Gas Engineering, 27 Lathrop St., Madison, Wis. 1911
Lawrance, C. H., Assistant Professor of Applied Mechanics, Purdue University, LaFayette, Ind. 1906
Lawrence, C. W., Professor of Civil Engineering, University of Southern California, Los Angeles, Cal.......................... 1909
Lawrence, R. R., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1907
Laws, F. A., Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass. 1909
Lawton, E. E., Associate Professor of Electrical Engineering, Syracuse University, Syracuse, N. Y. 1910
LeConte, J. N., Professor of Engineering Mechanics, University of California, Berkeley, Calif. 1913
Leete, J. H., Director, Carnegie Library of Pittsburgh, Pittsburgh, Pa. 1907
Lekberg, C. H., Associate Professor of Mechanical Engineering, University of Maine, Orono, Me. 1912
Leland, O. M., Assistant Professor of Astronomy and Geodesy and Head of Dept. of Topographic and Geodetic Engineering, Cornell University, Ithaca, N. Y.......................... 1908
Lendall, H. N., Assistant Professor of Civil Engineering, Rutgers College, New Brunswick, N. J. 1912

LePage, Clifford B., Assistant Professor of Physics, Stevens Institute of Technology, Hoboken, N. J.	1908
Lester, O. C., Professor of Physics, University of Colorado, Boulder, Colo.	1912
LeTellier, L. S., Professor of Drawing, The Citadel, The Military College of South Carolina, Charleston, S. C.	1912
Leutwiler, O. A., Professor of Machine Design, University of Illinois, Urbana, Ill.	1906
Lewis, F. J., Instructor in Civil Engineering, The Rice Institute, Houston, Tex.	1916
Lewis, J. F., Electrical and Railway Engineer, 505 Brinton St., Germantown, Philadelphia, Pa. (Life Member)	1913
Lieb, J. W., Vice-President, The New York Edison Co., 124 E. 15th St , New York, N. Y.	1911
Light, J. J., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa.	1917
Lilly, S. B., Assistant Plant Engineer, Merchant Shipbuilding Corporation, Swarthmore, Pa.	1913
Lincoln, P. M., Director of the Dept. Electrical Engineering, University of Pittsburgh; Commercial Engineer, Westinghouse E. & M. Co., East Pittsburgh, Pa.	1911
Lindemann, C. A., Professor of Applied Mathematics, Bucknell University, Lewisburg, Pa.	1905
Linville, C. P., Metallurgical Engineer American Smelting & Refining Co., Perth Amboy, N. J.	1904
Little, C. N., Dean of the College of Engineering and Professor of Civil Engineering, University of Idaho, Moscow, Idaho	1907
Little, G. T., Instructor, Portland High School, Electrical Department, Portland, Maine	1916
Lockwood, E. H., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn.	1908
Lodge, W. L., Associate Professor of Physics, Michigan Agricultural College, East Lansing, Mich.	1908
Logan, D. M., Assistant in Mechanical Drawing, University of Oklahoma, Norman, Okla.	1916
Long, J. J., Assistant Professor of Civil Engineering, University of Cincinnati, Cincinnati, O.	1911
Longyear, J. M., Member Board of Control, Michigan College of Mines, Marquette, Mich.	1905
Lory, C. A., President, State Agricultural College of Colorado, Fort Collins, Colo.	1908
Love, A. C., Professor of Railway Engineering, Texas A. & M. College, College Station, Texas	1900

Luby, Wm. A., Head of Dept. of Mathematics, Kansas City Polytechnic Institute, Kansas City, Mo. 1914

Lucke, C. E., Professor of Mechanical Engineering and Head of Dept., Columbia University, New York, N. Y. 1906

Luderitz, Joao, Engenheiro Chefo-Instituto Technico Professional, Porto Alegre, Brazil 1909

Ludy, L. V., Professor of Experimental Engineering, Purdue University, LaFayette, Ind. 1903

Lund, Jacob, Supt. Heat and Power Dept., Kansas State Agricultural College, Manhattan, Kans. 1910

Lundgren, Leonard, District Engineer, U. S. Forest Service, Beck Bldg., Portland, Ore. 1907

Luther, H. B., Instructor in Civil Engineering, Massachusetts Institute of Technology, Boston, Mass. 1914

Lyle, Wm. T., Professor of Municipal Engineering, Lafayette College, Easton, Pa. 1914

Lyman, Richard R., Professor of Civil Engineering, University of Utah, Salt Lake City, Utah 1908

Lynch, D. E., Instructor in Forging, Foreman, Blacksmith Shop, Kansas State Agricultural College, Manhattan, Kans. 1915

McAdams, Edward E., Associate Professor of Civil Engineering, A. & M. College of Texas, College Station, Tex. 1918

McAlister, E. H., Professor of Mechanics, University of Oregon, Eugene, Ore. 1911

McAllister, A. S., Electrical Engineer, Engineers' Club, New York, N. Y. 1911

McCaffery, R. S., Professor of Metallurgy, University of Wisconsin, Madison, Wis. 1911

McCandliss, E. S., Assistant Professor of Civil Engineering, University of Missouri, School of Mines and Metallurgy, Rolla, Mo. 1915

McCandliss, L. C., Assistant Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

McCann, Wm. R., Assistant Purchasing Officer, Emergency Fleet Corporation, Washington, D. C. 1912

McCaustland, E. J., Dean, School of Engineering, and Director Engineering Experiment Station, University of Missouri, Columbia, Mo. 1902

McClelland, E. H., Technology Librarian, Carnegie Library of Pittsburgh, Pittsburgh, Pa. 1912

McClelland, J. F., Professor of Mining Engineering, Yale University, New Haven, Conn. 1912

McClintic, H. H., Vice-President and General Manager, McClintic-Marshall Construction Co., Pittsburgh, Pa. 1910

McComb, Dana, Q., Testing and Inspecting Engineer, 215 Clark Bldg., Birmingham, Ala.	1916
McCormick, C. M., Instructor in Electrical Engineering, University of Colorado, Boulder, Colo.	1917
McCormick, E. B., Mechanical Engineer, Office of Public Roads and Rural Engineering, U. S. Dept. of Agriculture, Washington, D. C.	1908
McCormick, S. B., Chancellor, University of Pittsburgh, Pittsburgh, Pa.	1914
McCullough, F. M., Associate Professor of Civil Enginering, Carnegie Institute of Technology, Pittsburgh, Pa.	1910
McDaniel, A. B., Professor of Civil Engineering, Union College, Schenectady, N. Y.	1907
McDonald, P. B., Instructor in Engineering English, University of Colorado, Boulder, Colo.	1917
McEachnon, K. B., Professor of Electrical Engineering, Ohio Northern University, Ada, O.	1916
McFarland, David F., Associate Professor of Applied Chemistry, University of Illinois, Urbana, Ill.	1914
McGowan, John, Professor of Applied Mechanics, University of Toronto, Toronto, Ont., Canada	1914
McGrath, E. L., Instructor in Engineering Mathematics, University of Colorado, Boulder, Colo.	1916
McKergow, C. M., Associate Professor of Mechanical Engineering, McGill University, Montreal, Canada.	1913
McKibben, F. P., Professor of Civil Engineering, Lehigh University, South Bethlehem, Pa.	1904
McLeod, D. F., Assistant Professor of Civil Engineering, University of Mississippi, University, Miss.	1915
McMillin, Emerson, Chairman, Board of Directors, American Light & Traction Co., and President of many Companies, Ramsey, N. J. (Life Member)	1911
McNair, F. W., President, Michigan College of Mines, Houghton, Mich.	1897
McNair, G. B., Assistant Professor of Electrical Engineering, Colorado College, Colorado Springs, Colo.	1914
McNaugher, D. W., Partner, Robert W. Hunt & Co., Engineers, Pittsburgh, Pa.	1910
McNown, W. C., Associate Professor of Civil Engineering, University of Kansas, Lawrence, Kans.	1915
McRae, A. L., Director and Professor of Physics, Missouri School of Mines, Rolla, Mo.	1907
Macarthur, J. R., Professor of English, Kansas State Agricultural College, Manhattan, Kans.	1915

MacCracken, J. H., President, Lafayette College, Easton, Pa.... 1913

Macdonald, S. L., Head of the Department of Mathematics, Colorado State Agricultural College, Ft. Collins, Colo............. 1914

Mack, J. G. D., Professor of Machine Design, University of Wisconsin, Madison, Wis. 1901

MacKavanaugh, T. J., Associate Professor of Electrical Engineering, Catholic University of America, Washington, D. C. 1916

MacKay, H. M., Professor of Civil Engineering, McGill University, Montreal, Quebec, Canada 1914

Mackenzie, C. J., Professor of Civil Engineering, University of Saskatchewan, Saskatoon, Sask., Canada 1915

Maclaurin, R. C., President, Massachusetts Institute of Technology, Cambridge, Mass. 1909

MacNaughton, **Edgar**, Instructor in Mechanical Engineering, Tufts College, Tufts College, Mass. 1916

MacNaughton, **Jas.**, Vice-President and General Manager, Calumet and Hecla Mines; Member Board of Control, Michigan College of Mines, Calumet, Mich. 1905

MacNutt, **Barry**, Professor of Physics, Lehigh University, South Bethlehem, Pa. 1910

Macomber, G. S., Assistant Electrical Engineer, Bureau of Standards, Washington, D. C. 1904

Magnusson, C. E., Professor of Electrical Engineering, University of Washington, Seattle, Wash............................ 1907

Magruder, **Wm.** T., Professor of Mechanical Engineering, The Ohio State University, Columbus, O. 1893

Main, C. T., Consulting and Constructing Engineer, 14 Herrick St., Winchester, Mass. 1911

Mallory, **Francis**, Professor of Physics and Electrical Engineering, Virginia Military Institute, Lexington, Va. 1912

Mallory, W. F., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. 1915

Mann, C. A., Associate Professor of Chemical Engineering, Iowa State College, Ames, Ia. 1917

Mann, C. L., Professor of Civil Engineering, North Carolina State College of Agriculture and Engineering, West Raleigh, N. C. 1917

Mann, C. R., The Carnegie Foundation for the Advancement of Teaching, 576 Fifth Ave., New York, N. Y. 1914

Mann, C. V., Instructor in Engineering Mathematics, University of Colorado, Boulder, Colo. 1916

Marburg, **Edgar**, Professor of Civil Engineering, University of Pennsylvania, Philadelphia, Pa. 1894

Mark, **Robert** M., Civil Engineer, Highways, Spencerport, Monroe Co., N. Y. 1909

Marker, J. R., Chief Engineer, Ohio Paving Brick Mfgrs. Association, Columbus, O. 1913

Marks, L. S., Professor of Mechanical Engineering, Harvard University, and Massachusetts Institute of Technology, Cambridge, Mass. 1909

Marquis, F. W., Professor of Steam Engineering, Ohio State University, Columbus, Ohio 1910

Marr, Robt. A., Dean of the Engineering Department, Virginia Polytechnic Institute, Blacksburg, Va. 1912

Marston, Anson, Dean of the Division of Engineering and Director of the Engineering Experiment Station, and Professor of Civil Engineering, Iowa State College, Ames, Ia. 1894

Martel, R. R., Assistant Engineer, Sayles Finishing Plants, Saylesville, R. I. 1915

Martenis, J. Van S., Assistant Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1908

Martin, L. A., Jr., Dean and Professor of Mechanics, Stevens Institute of Technology, Hoboken, N. J. 1907

Martin, T. C., Secretary, The National Electric Light Association, 29 West 39th St., New York, N. Y. 1909

Martin, W. H., Assistant Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. 1913

Martinson, C. G., Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1918

Marvin, Henry H., Professor of Physics, Tufts College, Tufts College, Mass. 1914

Marx, C. D., Professor of Civil Engineering, Leland Stanford Junior University, Stanford University, Calif. 1893

Mason, A. J., Engineer, Chicago Railway Exchange, 5715 Woodlawn Ave., Chicago, Ill. 1912

Matheson, K. G., President, Georgia School of Technology, Atlanta, Ga. 1916

Mathews, H. B., Professor of Physics, South Dakota State College of A. and M. Arts, Brookings, S. D. 1896

Mathews, Raymond, Assistant Professor of Civil Engineering, University of Mississippi, University, Miss. 1918

Mathews, R. M., Instructor in Mathematics, Riverside Jr. College, Riverside, Calif. 1917

Mathewson, Jas. S., Engineer in Forest Products, U. S. Forest Products Laboratory, Madison, Wis. 1914

Matte, Luis, Civil Engineer, Agustinas 1319, Santiago, Chile ... 1917

Matthews, Robertson, Assistant Professor of Power Engineering, Cornell University, Ithaca, N. Y. 1910

Maurer, E. R., Professor of Mechanics, University of Wisconsin, Madison, Wis. 1897

Mavity, V. T., Instructor in Electrical Engineering, University of Cincinnati, Cincinnati, O. 1917

May, **Chas.** C., Instructor in Civil Engineering, University of Washington, Seattle, Wash. 1912

Mead, D. W., Professor of Hydraulic and Sanitary Engineering, University of Wisconsin, Madison, Wis. 1908

Mease, J. A., Associate Professor of Machine Design, Pennsylvania State College, State College, Pa. 1909

Meeker, W. H., Professor of Mechanical Engineering, Iowa State College, Ames, Ia. 1903

Mees, C. L., President, Rose Polytechnic Institute, Terre Haute, Ind. 1894

Méhely, **Kálmán**, Director of the Society of Hungarian Ironworks and Machinery Factories, Budapest, Hungary.............. 1909

Meiklejohn, **Robert**, Assistant Professor of Engineering Drawing, Ohio State University, Columbus, O....................... 1909

Meller, H. B., Dean, School of Mines, Professor of Mining, University of Pittsburgh, Pittsburgh, Pa. 1915

Mendenhall, T. C., 329 N. Chestnut St., Ravenna, O. (Honorary Member) 1895

Merrill, J. F., Director of the Utah State School of Mines and Engineering; Professor of Physics and Electrical Engineering, University of Utah, Salt Lake City, Utah 1907

Merrill, J. L., Instructor in Mechanical Drawing, University of Colorado, Boulder, Colo. 1915

Merriman, **Mansfield**, 1071 Madison Ave., New York, N. Y..... 1893

Meyer, **Adolph** F., Associate Professor of Hydraulic Engineering, University of Minnesota, Minneapolis, Minn. 1913

Mickey, **Clark** E., Associate Professor of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebr. 1912

Mickle, **Frank** A., Instructor in Descriptive Geometry and Drawing, University of Michigan, Ann Arbor, Mich. 1917

Millar, A. V., Assistant Professor of Drawing, University of Wisconsin, Madison, Wis. 1914

Miller, **Dayton** C., Professor of Physics, Case School of Applied Science, Cleveland, O. 1907

Miller, **Hugh**, Lecturer in Civil Engineering, Rice Institute, Houston, Tex. 1909

Miller, H. W., Assistant Dean, College of Engineering, and Assistant Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1912

Miller, N. C., Supervisor, Training Schools, Chester Shipbuilding Co., Chester, Pa. 1914

Miller, S. O., Assistant Professor of Engineering Drafting, Columbia University, New York, N. Y. 1917

Miser, W. L., Assistant Professor of Mathematics, University of Arkansas, Fayetteville, Ark. 1914

Mitcham, G. N., Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1906

Mitchell, Louis, Associate Professor of Civil Engineering, Syracuse University, Syracuse, N. Y. 1913

Molby, F. A., Assistant Professor of Physics, Indiana University, Bloomington, Ind. 1910

Monroe, W. K., Manager, Engineering Dept., The Brown Hoisting Machinery Co., Cleveland, O. 1911

Moody, L. F., Consulting Engineer, I. P. Morris Dept., Wm. Cramp & Sons, Ship and Engineering Building Co., Philadelphia, Pa. 1912

Moomaw, Dalton, Road Engineer, Cuyahoga Co., 1315 Lakeview Road, N. E., Cleveland, O. 1911

Moore, F. C., Associate Professor of Mathematics, New Hampshire College of A. & M. Arts, Durham, N. H. 1915

Moore, G. R., Civil Engineer, Manasquan, N. J. 1913

Moore, H. F., Professor of Engineering Materials, University of Illinois, Urbana, Ill. 1905

Moore, Stanley H., Director of Mechanic Arts, McKinley High School, St. Louis, Mo. 1902

More, Chas. C., Professor of Civil Engineering, University of Washington, Seattle, Wash. 1901

Morecroft, J. H., Associate Professor of Electrical Engineering, Columbia University, New York, N. Y. 1908

Moritz, R. E., Professor of Mathematics, University of Washington, Seattle, Wash. 1917

Morrill, J. B., Manager, Reed Reduction Co., Palo Alto, Calif. .. 1914

Morris, C. C., Professor of Mathematics, The Ohio State University, Columbus, O. 1915

Morris, C. T., Professor of Structural Engineering, The Ohio State University, Columbus, O. 1907

Morris, J. J., Professor of Mechanical Constructive Practice, University of Pennsylvania, Philadelphia, Pa. 1912

Morrison, I. F., Lecturer in Structural Engineering, University of Alberta, Edmonton South, Alta., Canada 1912

Morrison, Roger L., Professor of Highway Engineering, Texas A. & M. College, College Station, Tex. 1914

Morrow, L. W. W., Professor of Electrical Engineering, Director, School of Electrical Engineering, University of Oklahoma, Norman, Okla. 1917

Morse, G. H., Consulting Engineer, Mutual Electric & Machine Co., Wheeling, W. Va. 1907

Morse, J. L., Professor of Mechanical Engineering, Colorado School of Mines, Golden, Colo. 1910

Morss, Everett, 115 Commonwealth Ave., Boston, Mass. 1910

Moseley, A. W., Professor of Mechanical Engineering, Lewis Institute, Chicago, Ill. 1907

Moss, S. A., Engineer, Turbine Research Dept., General Electric Co., Lynn, Mass. 1911

Mott, W. E., Dean, School of Applied Science, Carnegie Institute of Technology, Pittsburgh, Pa. 1907

Mounce, J. L., Instructor in Wood Working, University of Pennsylvania, Philadelphia, Pa. 1912

Moyer, J. A., Director of the Dept. of University Extension, Massachusetts Board of Education, Boston Mass. 1904

Moyle, M. W., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. 1915

Muhlfeld, J. E., Sherbrooke Road, Scarsdale, N. Y. 1911

Munn, D. W., Assistant Engineer, Steel Company of Canada, Montreal, Canada 1915

Munro, A. R., Senior Demonstrator in Engineering, University of Queensland, Brisbane, Australia 1913

Munro, G. W., Assistant Professor of Mechanical Engineering, Purdue University, LaFayette, Ind. 1915

Munro, M. S., Assistant Professor of Electrical Engineering, Tufts College, Tufts College, Mass. 1914

Munroe, G. E., Construction Department, General Electric Co., Schenectady, N. Y. 1907

Munroe, H. S., Emeritus Professor of Mining, Columbia University, Litchfield, Conn. 1893

Murdock, H. E., Agricultural Engineer, Head of Agricultural Engineering Department, University of Montana, Bozeman, Mont. 1910

Murphy, R. K., % P. R. Cole, Sydney Teachers College, Sydney, Australia 1914

Murray, D. A., Professor of Applied Mathematics, McGill University, Montreal, Canada 1910

Murrie, J. L., Supervisor, Cadet Engineer Corps, The New York Edison Co., New York, N. Y. ....

Myers, Curtis C., Professor of Industrial Engineering, University of Cincinnati, Cincinnati, O. 1914

NAGLE, J. C., Professor of Civil Engineering, Dean of Engineering and Director, Engineering Experiment Station, A. & M. College of Texas, College Station, Tex. 1897

NAIDU, A. S., Assistant Engineer, Vizianagram City, Vizagapatam District, Madras, India 1913

NAIDU, K. S., Manager, Samasthanam Engineer's Office, Vizianagram City, Madras, South India 1914

NASH, C. A., Instructor in Electrical Engineering, Armour Institute of Technology, Chicago, Ill. 1913

NEEL, WM. T., Assistant to Supt. of Installation Dept., Philadelphia Electric Co., Philadelphia, Pa. 1914

NEFF, F. H., Professor of Civil Engineering, Case School of Applied Science, Cleveland, O. 1895

NELSON, J. H., Professor of Applied Mechanics, Worcester Polytechnic Institute, Worcester, Mass. 1910

NELSON, J. R., Assistant Professor of English in the Colleges of Engineering and Architecture, University of Michigan, Ann Arbor, Mich. 1914

NESBIT, A. F., Consulting Engineer; Special Lecturer in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1902

NESBITT, RUSSELL B., Instructor in Civil Engineering, Pennsylvania State College, State College, Pa. 1917

NEWCOMB, REXFORD, Assistant Professor of Architecture and Architectural Engineering, A. & M. College of Texas, College Station, Tex. 1917

NEWCOMBE, J. L., Professor of Civil Engineering, University of Virginia, University, Va. 1915

NEWELL, F. H., Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1915

NEWHALL, A. B., Instructor of Applied Science, Wentworth Institute, Boston, Mass. 1912

NEWKIRK, B. L., Assistant Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota, Minneapolis, Minn. 1908

NEWMAN, C. M., Professor of English and Dean, Academic Dept., Virginia Polytechnic Institute, Blacksburg, Va. 1917

NEWTON, GUY D., Assistant Professor of Mechanical Drawing and Descriptive Geometry, University of Missouri, Columbia, Mo. .. 1913

NICHOLS, CHAS. S., Assistant to Dean and Director, Division of Engineering, Associate Professor of Civil Engineering, in charge of Sanitary Engineering, Iowa State College, Ames, Ia. 1915

NOBLE, H. P., Consulting and Contracting Engineer, Falls Church, Va. 1908

Nold, H. E., Assistant Professor of Mining Engineering, The Ohio State University, Columbus, O. 1916

Norris, H. H., Associate Editor, *Electric Railway Journal*, 239 W. 39th St., New York, N. Y. 1900

Norman, Carl A., Professor of Machine Design, The Ohio State University, O. 1918

Northcott, J. A., Associate Professor of Mathematics, Syracuse University, Syracuse, N. Y. 1915

Norton, A. E., Assistant Professor of Engineering Drawing, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass. 1910

Norton, C. L., Massachusetts Institute of Technology, Cambridge, Mass. 1908

Nottingham, A. R., M. E. Dept., Purdue University, W. LaFayette, Ind. 1910

Nugent, P. C., Professor of Civil Engineering, Syracuse University, Syracuse, N. Y. 1914

Nyswander, R. E., Professor of Physics, University of Denver, Denver, Colo. 1912

Ockerblad, A. M., Examiner of Surveys in the U. S. Dept. of Agriculture, Forest Service, Washington, D. C. 1911

Oglesby, E. J., Professor of Mathematics, College of William and Mary, Williamsburg, Va. 1915

Oglesby, N. E., Instructor in Chemistry, University of Virginia, University, Va. 1915

Ohle, E. L., Professor of Mechanical Engineering, Washington University, St. Louis, Mo 1905

Olmsted, Chas. T., Instructor in Applied Mechanics and Hydraulics, Case School of Applied Science, Cleveland, O. 1914

Olsen, Tinius, President, Tinius Olsen Testing Machine Co., 500 N. 12th St., Philadelphia, Pa. 1907

Olson, O. A., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Ia. 1915

O'Neill, J. F., Instructor, Mechanical Engineering Dept., Massachusetts Institute of Technology, Cambridge, Mass. 1912

Orth, H. D., Assistant Professor of Mechanical Drawing, University of Wisconsin, Madison, Wis. 1910

Orton, Edward, Jr., Research Professor of Ceramic Engineering, The Ohio State University, Columbus, O. 1900

Osborn, G. M., Instructor in Sanitary Engineering, West Virginia University, Morgantown, W. Va. 1916

Osborne, L. A., Vice-President, Westinghouse Electric & Mfg. Co., 165 Broadway, New York, N. Y. 1911

O'SHAUGHNESSY, LOUIS, Instructor in Mathematics, University of Pennsylvania, Philadelphia, Pa. 1912

OSSA, GASTON, Assistant in Physics, Universidad de Chile, Santiago, Chile, S. A. 1911

OSTRANDER, J. E., Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College, Amherst, Mass. 1894

OWENS, R. B., Secretary of The Franklin Institute, Philadelphia, Pa. 1894

OWENS, R. H., Assistant Professor of Practical Mechanics, Purdue University, LaFayette, Ind. 1917

PAINE, ELLERY B., Professor of Electrical Engineering and Acting Head of the Department, University of Illinois, Urbana, Ill. 1911

PAINE, FRANK D., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Ia. 1915

PARCEL, J. I., Associate Professor of Structural Engineering, University of Minnesota, Minneapolis, Minn. 1910

PARK, C. F., Professor of Mechanism, Director of the Mechanical Laboratories, Director of Lowell Institute School for Industrial Foremen, Massachusetts Institute of Technology, Boston, Mass. 1903

PARK, C. W., Associate Professor of English, University of Cincinnati, Cincinnati, O. 1915

PARKER, J. C., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1916

PARKIN, J. H., Lecturer in Mechanical Engineering, University of Toronto, Toronto, Ontario, Canada 1915

PARKS, C. W., Civil Engineer, United States Navy, Chief of Bureau of Yards and Docks, Washington, D. C. 1911

PARMELEE, H. C., Managing Editor, *Metallurgical and Chemical Engineering,* New York, N. Y. 1916

PARR, S. W., Professor of Applied Chemistry, University of Illinois, Urbana, Ill. 1912

PASSANO, L. M., Associate Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1912

PATTEN, W. E., Professor of Civil Engineering, Government Institute of Technology, Shanghai, China 1915

PATTERSON, L. L., Professor of Electrical Engineering, Mississippi A. & M. College, Agricultural College, Miss. 1915

PATTERSON, T. S., Assistant Professor of Mechanics and Materials of Construction, The Pennsylvania State College, State College, Pa. 1914

PAUL, C. E., Professor of Mechanics, Armour Institute of Technology, Chicago, Ill. 1907

PEARCE, C. E., Assistant Professor of Applied Mechanics and Machine Design, Kansas State Agricultural College, Manhattan, Kans. 1917

PEARSON, R. A., President, Iowa State College, Ames, Ia. 1914

PEGRAM, GEORGE B., Acting Dean, School of Mines, Engineering and Metallurgy, Professor of Physics, Columbia University, New York, N. Y. 1918

PEHRSON, E. W., Assistant Professor of Mathematics, University of Utah, Salt Lake City, Utah 1915

PENCE, W. D., Member, Engineering Board, Interstate Commerce Commission, Chicago, Ill. 1895

PENDER, HAROLD, Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 1909

PENN, J. C., Assistant Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill. 1915

PERRY, C. F., Supervisor of Manual and Industrial Training, Milwaukee Public Schools, Milwaukee, Wis. 1907

PERRY, F. G., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1916

PERRY, W. H., Instructor in Applied Science, Wentworth Institute, Boston, Mass. 1913

PERRY, WILLIAM S., Assistant Professor of Physics and Electrical Engineering, University of Florida, Gainesville, Fla. 1918

PERSON, F. G., Professor of Physics, Head, Dept. of Physics and Electrical Engineering, State Agricultural College, Fort Collins, Colo. 1918

PETTEE, C. H., Dean, New Hampshire College, Durham, N. H. 1898

PFEIF, G. H., Secretary, Student Committee, General Electric Co., Schenectady, N. Y. 1918

PHALEN, HAROLD R., Professor of Mathematics, Berea College, Berea, Ky. 1914

PHELON, J. O., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1902

PHELPS, HOWARD E., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1914

PHILBRICK, H. S., Professor of Mechanical Engineering, Northwestern University, Evanston, Ill. 1913

PHILLIPS, H. C., General Secretary, President's Conference on Federal Valuation of Railroads, 737 Commercial Trust Bldg., Philadelphia, Pa. 1913

PHILLIPS, J. D., Assistant Dean, College of Engineering, and Professor of Drawing, University of Wisconsin, Madison, Wis. 1899

PICKELS, G. W. JR., Associate in Civil Engineering, University of Illinois, Urbana, Ill. 1910

PINTO, ANTHONY, Assistant Professor of Electrical Engineering, Cooper Union, New York, N. Y.	1913
PIPER, FRED. F., Instructor in Electrical Engineering, Mechanics Institute, Rochester, N. Y.	1915
PLAGGE, H. J., Assistant Professor of Physics, Iowa State College, Ames, Ia.	1915
PLANT, L. C., Head of the Department of Mathematics, Michigan Agricultural College, East Lansing, Mich.	1914
POND, FRANCIS J., Professor of Chemistry and Director of Chemical Laboratory, Stevens Institute of Technology, Hoboken, N. J.	1912
POND, G. G., Dean of the School of Natural Science, The Pennsylvania State College, State College, Pa.	1914
POOLE, CECIL P., Consulting Engineer, P. O. Box 774, Atlanta, Ga.	1907
POORMAN, A. P., Assistant Professor of Applied Mechanics, Purdue University, LaFayette, Ind.	1907
POPE, WILLARD, Vice-President and Engineer, The Canadian Bridge Co., Ltd., Walkerville, Ontario	1911
PORTER, CHAS. T., Instructor in Mechanical Engineering, Yale University, New Haven, Conn.	1912
PORTER, DWIGHT, Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Cambridge, Mass.	1893
PORTER, F. M., Associate in Engineering Drawing, University of Illinois, Urbana, Ill..	1912
PORTER, H. E., Assistant Professor of Mathematics, Kansas State Agricultural College, Manhattan, Kans.	1915
PORTER, J. B., Professor of Mining Engineering, McGill University, Montreal, Quebec, Canada	1904
PORTER, J. F., President, Kansas City Light & Power Co., and Standard Electric Light Co., Kansas City, Mo.	1912
PORTER, J. MADISON, Consulting Engineer, Easton, Pa.	1893
PORTER, R. A., Professor of Physics, Syracuse University, Syracuse, N. Y.	1908
PORTER, R. H., Professor of Mechanical Engineering, New Hampshire College, Durham, N. H.	1915
POTTER, A. A., Professor of Steam and Gas Engineering and Dean of the Engineering Division, Kansas State Agricultural College, Manhattan, Kans.	1908
POTTER, JOHN C., 257 Maple Ave., Oak Park, Ill.	1913
POUND, J. H., Instructor in Mechanical Engineering, Rice Institute, Houston, Tex.	1916
POWERS, W. P., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y.	1914
PRATT, H. B., Test Engineer, Public Service Commission, Harrisburg, Pa.	1915

PRATT, J. A., Director, Williamson Free School of Mechanical Trades, Delaware Co., Pa.	1908
PRENTICE, D. B., Head of Mechanical Engineering Department, Lafayette College, Easton, Pa.	1912
PRESS, ABRAHAM, Assistant Professor of Electrical Engineering, University of Oklahoma, Norman, Okla.	1916
PRICE, CHAS. B., Instructor in Mathematics and Drawing, Boys Trade School; Assistant Supervisor of Evening Trade School, Worcester Trade School, Worcester, Mass.	1914
PRIME, A. C., Consulting Engineer, 1008 Spruce St., Philadelphia, Pa. (Life Member)	1910
PRINE, CHARLES W., Instructor in Physics, Carnegie Institute of Technology, Pittsburgh, Pa.	1918
PRITCHARD, S. R., Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va.	1914
PROBERT, F. H., Professor of Mining, University of California, Berkeley, Calif.	1917
PRYOR, F. L., Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J.	1908
PULLEN, M. W., Instructor in Electrical Engineering, Johns Hopkins University, Baltimore, Md.	1909
PURYEAR, CHARLES, Dean and Professor of Mathematics, Texas A. and M. College, College Station, Texas	1901
PUTNAM, WM. J., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.	1918
RABER, B. F., Associate Professor of Mechanical Engineering, University of California, Berkeley, Cal.	1915
RADEBAUGH, GUSTAV H., Associate in Factory Management and Machine Shop Practice, Acting Director Shop Laboratories, University of Illinois, Urbana, Ill.	1914
RALSTON, J. C., Consulting Engineer, also Vice-President and Consulting Engineer, Pacific Coast Pipe Co. of Seattle, 2421 W. Mission Ave., Spokane, Wash.	1910
RANDALL, J. A., 2860 Scottwood Ave., Toledo, O.	1911
RANDALL, O. E., Professor of Applied Mathematics and Dean of the University, Brown University, Providence, R. I.	1903
RANDOLPH, L. S., Professor of Mechanical Engineering and Dean of Engineering Dept., Virginia Polytechnic Institute, Blacksburg, Va.	1894
RANDOLPH, OSCAR A., Instructor in Physics, University of Colorado, Boulder, Colo.	1917
RANKIN, F. J., Electrical Engineer, Public Utilities Commission, Capitol Bldg., Denver, Colo.	1913

RASMUSEN, J. E., Associate Professor of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebr. 1910

RAY, H. C., Professor of Ore Dressing and Associate Professor of Metallurgy, University of Pittsburgh, Pittsburgh, Pa. 1916

RAYMOND, F. N., Associate Professor of Rhetoric, University of Kansas, Lawrence, Kans. 1910

RAYMOND, H. M., Dean, Engineering Studies, Armour Institute of Technology, Chicago, Ill. 1903

RAYMOND, W. G., Dean of the College of Applied Science and Professor of Civil Engineering, State University of Iowa, Iowa City, Ia. 1893

RAYNER, WM. H., Associate in Civil Engineering, University of Illinois, Urbana, Ill. 1913

READ, B. K., Chief Engineer, Dominion Forge & Stamping Co., Ltd., Walkerville, Ont. 1913

REBER, LOUIS E., Dean, University Extension Division, University of Wisconsin, Madison, Wis. 1893

REED, K. W., Principal, Apprentice School Warner & Swasey Co., Cleveland, O. 1915

REED, PERCY L., Senior Instructor in Civil Engineering, Drexel Institute, Philadelphia, Pa. 1914

REID, CLARENCE E., Professor of Electrical Engineering, Kansas State Agricultural College, Manhattan, Kans. 1907

REMICK, B. L., Professor of Mathematics, Kansas State Agricultural College, Manhattan, Kans. 1915

REW, IRWIN, Trustee of Northwestern University, 108 LaSalle St., Chicago, Ill. 1913

RICE, H. A., Professor of Mechanics and Structural Engineering, University of Kansas, Lawrence, Kans. 1915

RICHARDS, C. RUSS, Dean, College of Engineering, Director, Engineering Experiment Station and Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1895

RICHARDS, CHAS. RUSSELL, Director, Cooper Union, New York, N. Y. 1904

RICHARDS, T. E., Instructor, Michigan College of Mines, Houghton, Mich. 1910

RICHARDS, WM. H., Instructor in Manual Training and Pattern Making, University of Minnesota, Minneapolis, Minn. 1910

RICHARDSON, CLIFFORD, Consulting Engineer, Room 1615 Woolworth Bldg., 233 Broadway, New York, N. Y. 1913

RICHARDSON, G. R., Instructor in Steam Engineering, Franklin Union, Boston, Mass. 1912

RICHARDSON, M. R., Durham, N. C. 1910

RICHEY, J. J., Associate Professor of Civil Engineering, Texas A. & M. College, College Station, Tex. 1910

RICHTER, A. W., Dean of the College of Engineering, University of Montana, Bozeman, Mont. 1894

RICHTMYER, F. K., Assistant Professor of Physics, Cornell University, Ithaca, N. Y. 1910

RICKER, N. C., Emeritus Professor of Architecture, University of Illinois, Urbana, Ill. 1894

RIDDERVOLD, A. S., Assistant Professor of Civil Engineering, University of Nebraska, Lincoln, Nebr. 1912

RIDOUT, JOHN, Instructor in Mathematics, United States Naval Academy, Annapolis, Md. 1915

RIESENBERGER, ADAM, Registrar and Treasurer, Stevens Institute of Technology, Hoboken, N. J.................................. 1908

RIGGS, H. E., Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1913

RIGGS, N. C., Professor of Applied Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa. 1907

RIGGS, W. M., President and Consulting Professor of Engineering, Clemson Agricultural College of South Carolina, Clemson College, S. C. 1897

RISLEY, W. J., Professor of Mathematics, James Millikin University, Decatur, Ill. 1910

RITTENHOUSE, L. H., Associate Professor of Electrical Engineering, Haverford College, Haverford, Pa. 1906

ROBBINS, A. G., Professor of Topographical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1894

ROBBINS, F. A., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Ia. 1913

ROBERT, J. H., Instructor in Applied Mechanics and Machine Design, Kansas State Agricultural College, Manhattan, Kans. 1917

ROBERTS, MILNOR, Dean of the College of Mines, and Professor of Mining Engineering and Metallurgy, University of Washington, Seattle, Wash. 1910

ROBERTS, W. J., Chief Engineer, Inter-County River Improvement, 401 Court House, Tacoma, Wash. .... 19[illegible]

ROBERTSON, J. E., Head, Graphics Department, Colorado College, Colorado Springs, Colo. 1913

ROBERTSON, JOHN E., County Road Engineer of Shelby County, Shelbyville, Ky. 1914

ROBINSON, EDW., Professor of Mechanical Engineering, University of Vermont, Burlington, Vt. 1899

ROBINSON, M. B., Professor of Mechanical Engineering University of Akron, Akron, O. 1915

Rockwell, E. H., Professor of Structural Engineering, Tufts College, Tufts College, Mass. 1907

Rockwell, Robert L., Consulting Electrical Engineer, Stevens & Rockwell, Empire Bldg., Seattle, Wash. 1915

Rodgers, L. J., Head of Dept. of Machine Work, Wentworth Institute, Boston, Mass. 1912

Rodhouse, T. J., Associate Professor of Hydraulic Engineering, University of Missouri, Columbia, Mo. 1904

Rodman, W. S., Professor of Electrical Engineering, University of Virginia, University, Va. 1915

Roe, J. W., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1908

Rogers, C. E., Professor of Civil Engineering, Trinity College, Hartford, Conn. 1917

Rogers, H. S., Instructor in Civil Engineering, University of Washington, Seattle, Wash. 1917

Rogers, Ralph, Bay City, Mich. 1908

Rohrer, A. L., Electrical Superintendent, Schenectady Works, General Electric Co., Schenectady, N. Y. 1911

Rollins, E. B., Assistant Professor of Electrical Engineering, Tufts College, Tufts College, Mass. 1912

Rollins, Jas. W., President, Holbrook, Cabot & Rollins Corp., Contractors, Boston, Mass. 1913

Rondinella, L. F., Head of Department of Drawing and Design, West Philadelphia High School for Boys, Philadelphia, Pa. .. 1903

Rood, Jas. T., Professor (in charge) of Department of Electrical Engineering, Lafayette College, Easton, Pa. 1914

Root, J. E., Assistant Engineer, Division of Sewerage, Dept. of Public Service, Cincinnati, O. 1910

Root, R. E., Professor of Mathematics and Mechanics, Post-Graduate Dept., U. S. Naval Academy, Annapolis, Md. 1914

Rorty, M. C., Special Agent, American Telephone & Telegraph Co., 195 Broadway, New York, N. Y. 1912

Rosebrugh, T. R., Professor of Electrical Engineering, University of Toronto, Toronto, Ontario, Canada.......... 1896

Rosing, Anton S., Civil Engineer, 7229 North Robey St., Chicago, Ill. 1911

Rowell, L. D., Associate Professor of Electrical Engineering, Purdue University, LaFayette, Ind. 1910

Rowland, Arthur J., Dean and Professor of Electrical Engineering, Drexel Institute, Philadelphia, Pa. 1903

Rowley, F. B., Assistant Professor of Experimental Engineering, University of Minnesota, Minneapolis, Minn. 1910

Roys, F. W., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1914

Rubey, H. K., Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1917

Rugg, H. O., Instructor in Education, School of Education, University of Chicago, Chicago, Ill. 1909

Ruggles, S. L., Instructor in Civil Engineering, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. 1910

Running, Theodore R., Associate Professor of Mathematics, University of Michigan, Ann Arbor, Mich. 1918

Rusk, W. W., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. 1917

Russell, L. K., Professor of Chemistry, Clarkson School of Technology, Potsdam, N. Y. 1910

Russell, W. B., Director, Franklin Union, Boston, Mass. 1903

Ryan, H. J., Professor of Electrical Engineering, Leland Stanford Junior University, Stanford University, Calif. 1901

Ryan, W. T., Assistant Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn. 1911

Sadler, H. C., Professor of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Mich. 1907

Salazar, Arturo Edmundo, Professor of Applied Physics and Electrical Engineering, Universidad de Chile, Santiago de Chile, S. A. 1914

Sale, C. S., Assistant to Director, Engineering Experiment Station, and Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1916

Sanborn, F. E., Professor of Industrial Arts, Ohio State University, Columbus, O. 1899

Sanders, W. H., Instructor in Farm Motors, Kansas State Agricultural College, Manhattan, Kans. 1915

Sarason, Samuel D., Assistant Professor of Civil Engineering, L. C. Smith College of Applied Science, Syracuse University, N. Y. 1918

Satterfield, H. E., Professor of Mechanical Engineering, North Carolina State College, West Raleigh, N. C. 1909

Savant, D. P., Instructor in Electrical Engineering, University of Missouri, Columbia, Mo. 1917

Saville, Thorndike, Assistant in Municipal Administration and Geology, Harvard University, Cambridge, Mass. 1915

Sawyer, A. R., Professor of Electrical Engineering, Michigan Agricultural College, East Lansing, Mich. 1907

Sayre, M. F., Instructor in Engineering, Union College, Schenectady, N. Y. 1917

Scarborough, J. B., Instructor in Mathematics, U. S. Naval Academy, Annapolis, Md. 1915

Schealer, S. R., Assistant Professor of Electrical Engineering, Lehigh University, South Bethlehem, Pa. 1911

Schildhauer, Edward, President, The Stenotype Company, Indianapolis, Ind. 1912

Schmidt, E. C., Professor of Railway Engineering, University of Illinois, Urbana, Ill. 1907

Schneider, Herman, Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati, Cincinnati, O. 1903

Schuerman, W. H., Dean of the School of Engineering and Professor of Pure and Applied Mathematics, Vanderbilt University, Nashville, Tenn. 1895

Schwarze, C. T., Assistant Professor of Civil Engineering, Cooper Union, New York, N. Y. 1912

Scipio, L. A., Dean and Professor of Mechanical Engineering, Robert College, Constantinople, Turkey 1910

Scoates, Daniels, Professor of Agricultural Engineering, Mississippi A. & M. College, Agricultural College, Miss. 1914

Scott, C. F., Professor of Electrical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn. 1904

Scullen, A. J., In charge of Dept. of Civil Engineering, Catholic University of America, Washington, D. C., ... 1916

Searson, J. W., Professor of English, Kansas State Agricultural College, Manhattan, Kans. 1915

Seaton, L. F., Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1914

Seaton, R. A., Professor of Applied Mechanics and Machine Design, Kansas State Agricultural College, Manhattan, Kans. 1912

Seaver, H. L., Associate Professor of English, Massachusetts Institute of Technology, Cambridge, Mass. 1908

Seely, F. B., Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1913

Seery, Francis J., Assistant Professor of Civil Engineering, Cornell University, Ithaca, N. Y. 1908

Selby, L. B., Inspector, Ohio Inspection Bureau, Akron, O. 1911

Seward, H. L., Assistant Professor of Mechanical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn. 1910

Sexton, F. H., President of the Nova Scotia Technical College, and Director of Technical Education, Halifax, Nova Scotia 1908

Seyfert, S. S., Associate Professor of Electrical Engineering, Lehigh University, South Bethlehem, Pa. 1908

SHAAD, G. C., Professor of Electrical Engineering, University of Kansas, Lawrence, Kans. 1907

SHANE, ADOLPH, Dean of Engineering and Professor of Electrical Engineering, Highland Park College, Des Moines, Ia. 1907

SHATTUCK, E. L., Professor of Applied Mechanics and Thermodynamics, Louisiana Industrial Institute, Ruston, La. 1914

SHATTUCK, H. B., Associate Professor of Railroad Engineering, Pennsylvania State College, State College, Pa. 1906

SHAW, H. B., with Henry L. Doherty & Co., in charge Doherty Training Schools, Toledo, O. 1907

SHELDON, SAMUEL, Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y...... 1903

SHELDON, S. R., Dean and Professor of Electrical Engineering, Government Institute of Technology, Shanghai, China 1914

SHENEHON, FRANCIS C., Consulting Hydraulic Engineer, 628 Metropolitan Bank Bldg., Minneapolis, Minn. 1909

SHEPARDSON, G. D., Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn. 1895

SHEPARDSON, J. E., Instructor in Electrical Engineering, The Ohio State University, Columbus, O. 1917

SHEPPARD, H. S., Assistant Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1914

SHERMAN, C. E., Professor of Civil Engineering, Ohio State University, Columbus, Ohio 1907

SHIPLEY, S. C., Assistant Professor of Machine Construction, and Superintendent of Shops, University of Minnesota, Minneapolis, Minn. 1908

SHOOP, C. F., Assistant Professor of Experimental Engineering, University of Minnesota, Minneapolis, Minn. 1906

SHORT, R. L., Director of High Schools, Lakewood, O. 1902

SHUSTER, J. W., Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.................... 1907

SHUTT, J. C., Assistant Instructor in Steam and Gas Engineering, Kansas State Agricultural College, Manhattan, Kans. 1914

SIBLEY, F. H., Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1910

SILVEY, O. W., Professor of Physics, A. & M. College of Texas, College Station, Tex. 1917

SIMMERING, S. L., Assistant Professor of Steam and Gas Engineering, Kansas State Agricultural College, Manhattan, Kans. ... 1913

SJOGREN, OSCAR W., Assistant Professor of Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 1917

SKELTON, R. H., Professor of Civil Engineering, Pei-Yang University, Tientsin, China 1914

SLAGLE, W. C. H., Assistant Professor, University of Pennsylvania, Philadelphia, Pa. 1917

SLAYMAKER, P. K., Professor of Machine Design, University of Nebraska, Lincoln, Neb. 1910

SLEESMAN, L. C., Professor of Chemical Engineering, Ohio Northern University, Ada, O. 1917

SLICHTER, C. S., Professor of Applied Mathematics, University of Wisconsin; Consulting Engineer, Madison, Wis. 1906

SLICHTER, W. I., Professor of Electrical Engineering, Columbia University, New York, N. Y. 1911

SLOCUM, R. H., Professor of Civil Engineering, North Dakota Agricultural College, Agricultural College, N. D. 1903

SLUSS, A. H., Associate Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1915

SMALLWOOD, JULIAN C., Associate Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. 1912

SMITH, ARTHUR BESSEY, Electrical Engineer, The Automatic Electric Co., Chicago, Ill. 1911

SMITH, A. L., Professor of Drawing and Machine Design, Worcester Polytechnic Institute, Worcester, Mass. 1902

SMITH, E. B., Mechanical Engineer, Bureau of Soils, Washington, D. C. 1906

SMITH, H. B., Professor of Electrical Engineering, and Director of Electrical Engineering Dept., Worcester Polytechnic Institute, Worcester, Mass. 1898

SMITH, HARRY E., Professor of Steam Engineering, and Supt. of Power Plant, Texas A. & M. College, College Station, Tex..... 1895

SMITH, H. S. S., Professor of Civil Engineering, Princeton University, Princeton, N. J. 1894

SMITH, JAMES E., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1910

SMITH, J. E., Assistant Professor of Geology, Iowa State College, Ames, Ia. 1917

SMITH, J. HAMMOND, Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1910

SMITH, L. S., Professor of Topographic and Highway Engineering, University of Wisconsin, Madison, Wis. 1903

SMITH, P. F., Professor of Mathematics, Sheffield Scientific School, Yale University, New Haven, Conn. 1908

SMITH, R. J., Instructor, Department of Engineering, Louisiana Industrial University, Ruston, La. 1917

SMITH, RICHARD R., Manager, College Department, The Macmillan Company, 66 Fifth Ave., New York, N. Y. 1914

SMITH, S. A., Instructor in Dept. of Architecture, Kansas State Agricultural College, Manhattan, Kans.	1914
SMOLEY, C. K., Civil and Structural Engineer, International Textbook Co., Scranton, Pa.	1913
SMULL, T. J., JR., Executive Secretary of the University and Dean of the College of Engineering, Ohio Northern University, Ada, O.	1907
SMYTH, H. L., Professor of Mining and Metallurgy and Director of the Mining and Metallurgical Laboratory, Harvard University, Cambridge, Mass.	1907
SNADER, DAVID L., Professor in charge of Depts. of Engineering and Physics, Southwestern Presbyterian University, Clarkesville, Tenn.	1918
SNAVELY, T. R., Fellow of the Phelps Stokes Foundation, University of Virginia, University, Va.	1916
SNOW, CHAS. H., Dean of School of Applied Science and Professor of Civil Engineering, New York University, New York, N. Y.	1895
SNOW, O. L., Assistant Professor of Physics, Michigan Agricultural College, East Lansing, Mich.	1911
SNOW, WALTER B., Publicity Engineer, 136 Federal St., Boston, Mass.	1899
SOLBERG, H. C., Professor of Mechanical Engineering, South Dakota State College of A. and M. Arts, Brookings, S. D.	1894
SORENSEN, R. W., Professor of Electrical Engineering, Throop College of Technology, Pasadena, Calif.	1912
SPALDING, F. P., Professor of Civil Engineering, University of Missouri, Columbia, Mo.	1893
SPEIRS, CHAS. E., Vice-President, D. Van Nostrand Company, Publishers, 25 Park Place, New York, N. Y.	1914
SPERR, F. W., Professor of Civil and Mining Engineering, Michigan College of Mines, Houghton, Mich.	1896
SPERRY, C. S., Assistant Professor of Engineering Mathematics, University of Colorado, Boulder, Colo.	1914
SPINNEY, L. B., Professor of Physics, Iowa State College, Ames, Ia.	1899
POFFORD, C. M., Hayward Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.	1904
POONER, H. J., Director and Professor of Mechanical and Civil Engineering, Polytechnic School of Engineering, Regent St., W., London, England	1912
PRAGUE, EMBERT H., Associate Professor of Civil Engineering, University of Maine, Orono, Me.	1918
PRAGUE, F. J., Consulting Engineer, 165 Broadway, New York, N. Y.	1911

Springer, F. W., Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn. 1896

Springer, G. P., Assistant Professor of Civil Engineering, Maryland State College of Agriculture, College Park, Md. 1917

St. John, E. R., Designing Engineer, American Bridge Co., Pittsburgh, Pa. 1916

Stanford, J. V., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1907

Stanley, W. E., Instructor in Hydraulics Laboratory, Purdue University, LaFayette, Ind. 1915

Stanton, Chas. B., Assistant Professor of Railway Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1915

Staples, E. I., Instructor in Electrical Engineering, University of North Carolina, Chapel Hill, N. C. 1916

Starkey, L. C., Professor of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. 1914

Steele, J. N., Instructor in Foundry Work, Dickinson High School, Jersey City, N. J. 1912

Steinman, D. B., Professor in charge of Civil and Mechanical Engineering, College of the City of New York; Associate Engineer, Waddell & Son, 165 Broadway, New York, N. Y. 1910

Steinmetz, C. P., Chief Consulting Engineer, General Electric Co.; Professor of Electrophysics, Union University, Schenectady, N. Y. 1910

Stelzner, W. B., Adjunct Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. 1914

Stephenson, S. A., Jr., Assistant Professor of Civil Engineering, Rutgers College, New Brunswick, N. J. 1910

Stetson, J. M., Adelbert College, Western Reserve University, Cleveland, O. 1914

Stevens, A. C., General Electric Co., Pittsfield, N. Y. 1912

Stevens, E. F., Librarian, Pratt Institute Free Library, and Director, School of Library Science, Brooklyn, N. Y. 1908

Stevens, F. H., Assistant Professor Engineering Mechanics, College of Engineering, University of Michigan, Ann Arbor, Mich. 1915

Stevens, J. Floyd, Assistant Professor of Electrical Engineering, University of North Dakota, University, N. D. 1913

Stevens, W. LeConte, Professor of Physics, Washington & Lee University, Lexington, Va. 1916

Steward, R. K., Professor of Drawing and Design, Michigan Agricultural College, East Lansing, Mich. 1910

Stewart, C. E., Assistant Professor of Mechanic Arts, Franklin Union, Boston, Mass. 1908

Stewart, G. W., Professor of Physics, State University of Iowa, Iowa City, Ia. 1910

Stewart, L. B., Professor of Surveying and Geodesy, Faculty of Applied Science and Engineering, Toronto University, Toronto, Ontario, Canada. 1897

Stewart, O. M., Professor of Physics, University of Missouri, Columbia, Mo. 1909

Stillwell, L. B., Consulting Engineer, 100 Broadway, New York, N. Y. 1912

Stivers, E. R., Instructor in Civil Engineering, University of Florida, Gainesville, Fla. 1917

Stockwell, F. C., Assistant Professor of Electrical Engineering, Stevens Institute of Technology, Hoboken, N. J. 1914

Stoek, H. H., Professor of Mining Engineering, University of Illinois, Urbana, Ill. 1907

Stone, Chas. W., Consulting Engineer, General Electric Co., Schenectady, N. Y. 1911

Stone, E. A., Professor of General Engineering, Queen's University, Kingston, Ontario 1907

Stone, Julius F., c/o Seagrave Co., Columbus, O. 1913

Storm, E. R., Architect, 160 Fifth Ave., New York, N. Y. 1908

Stout, O. V. P., Dean of the College of Engineering and Professor of Civil Engineering, University of Nebraska, Lincoln, Neb. 1894

Straw, J. B., Assistant Professor of Electrical Engineering, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa. 1915

Strong, Albert J., Instructor in Machine Design and Supt. of Shops, University of Florida, Gainesville, Fla. 1913

Streeter, R. L., Professor of Steam and Gas Engine Design, Rensselaer Polytechnic Institute, Troy, N. Y. 1913

Sturges, T. L., Jr., Professor of Electrical Engineering, Delaware College, Newark, Del. 1910

Styer, Charles A., Instructor, U. S. Naval Academy, Annapolis, Md. 1918

Sullivan, Geo. L., Professor of Mechanical Engineering, University of Santa Clara, Santa Clara, Calif. 1912

Surveyer, Arthur, Consulting Engineer; Member, Board of Directors, Ecole Polytechnique de Montreal, Montreal, P. Q., Canada 1914

Sutherland, C. H., Instructor in Civil Engineering, Massachusetts Institute of Technology, Boston, Mass. 1914

Suttie, R. H., Instructor in Civil Engineering, Yale University, New Haven, Conn. 1912

Svensen, C. L., Assistant Professor of Engineering Drawing, The Ohio State University; Prop., Ohio Technical Drawing School, Columbus, O. 1909

Swain, G. F., Professor of Civil Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass. 1893

Swamy, B. N., Overseer, Town and Water Works, Berhamhere, Guajam, Madras, South India 1913

Swartzel, K. D., Professor of Mathematics, The Ohio State University, Columbus, O. 1910

Sweetser, E. O., Assistant Professor of Civil Engineering, Washington University, St. Louis, Mo. 1910

Sweetser, W. J., Professor of Mechanical Engineering, University of Maine, Orono, Me. 1910

Swett, G. W., Assistant Professor of Machine Design, Massachusetts Institute of Technology, Boston, Mass. 1907

Swift, Walter, Secretary, Department of Applied Science, University of Sheffield, Sheffield, England.......... 1902

Sypherd, W. O., Professor of English, Delaware College, Newark, Del. 1914

Talbot, Arthur N., Professor of Municipal and Sanitary Engineering, and in charge of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1893

Talbot, H. P., Professor of Inorganic Chemistry, Massachusetts Institute of Technology, Cambridge, Mass. 1902

Tallman, Wm. D., Professor of Mathematics, Montana State College of A. & M. Arts, Bozeman, Mont. 1914

Tanzer, E. Dean, Assistant Professor of Electrical Engineering, Georgia School of Technology, Atlanta, Ga. 1915

Taylor, I. I., Instructor in Applied Mechanics, Purdue University, LaFayette, Ind. 1915

Taylor, Knox, President, Taylor-Wharton Iron & Steel Co., High Bridge, N. J. 1916

Taylor, L. B., Torpedo Engineer, U. S. Naval Torpedo Station, Newport, R. I. 1912

Taylor, T. U., Professor of Civil Engineering and Dean of Engineering Department, University of Texas, Austin, Texas...... 1902

Taylor, W. C., Assistant Professor of Civil Engineering, Union University, Schenectady, N. Y. 1913

Taylor, Wm. E., Professor of Applied Mathematics and Head of Dept., College of Applied Science, Syracuse University, Syracuse, N. Y. 1913

Telleen, J. M., Assistant Professor of English, Case School of Applied Science, Cleveland, O. 1908

Temple, W. E. S., Consulting Engineer, Swarthmore, Pa. 1912

TERRELL, DANIEL V., Professor of Highway Engineering, University of Kentucky, Lexington, Ky. 1917

TERRELL, R. C., Associate Professor of Highway Engineering, University of Oklahoma, Norman, Okla. 1913

TERRILL, ARTHUR C., Head, Dept. of Mining Engineering, University of Kansas, Lawrence, Kans. 1916

THACH, C. C., President, Alabama Polytechnic Institute, Auburn, Ala. 1905

THALER, J. A., Professor of Electrical Engineering, Montana State College of A. and M. Arts, Bozeman, Mont. 1901

THAYER, H. R., Assistant Professor of Structural Design, Carnegie Institute of Technology, Pittsburgh, Pa. 1911

THOMAS, C. C., Head of the Department of Mechanical Engineering, Johns Hopkins University, Baltimore, Md. 1908

THOMAS, C. F., Instructor in Mathematics, Case School of Applied Science, Cleveland, O. 1909

THOMAS, CHAS. W., Instructor in Descriptive Geometry and Mechanical Drawing, Case School of Applied Science, Cleveland, O. 1912

THOMAS, EVAN, Professor of Mechanics and Mathematics, University of Vermont, Burlington, Vt. 1908

THOMAS, FRANKLIN, Professor of Civil Engineering, Throop College of Technology, Pasadena, Calif. 1914

THOMAS, GEO. B., Professor of Electrical Engineering, Colorado College, Colorado Springs, Colo. 1911

THOMAS, H. A., Associate Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1913

THOMAS, R. G., Professor of Mathematics and Engineering, The Citadel, The Military College of S. C., Charleston, S. C....... 1894

THOMAS, R. P., Assistant Professor of Applied Mathematics, University of Wooster, Wooster, O. 1914

THOMPSON, FRANK F., Professor of Electrical Engineering, Rutgers College, New Brunswick, N. J. 1909

THOMPSON, G. S., Assistant Professor of Rational and Technical Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y. 1907

THOMPSON, JAMES S., With McGraw-Hill Book Co., 239 W. 39th St., New York, N. Y. 1911

THOMSON, FRANCIS A., Dean, School of Mines, University of Idaho, Moscow, Ida. 1915

THOMSON, R. D., Efficiency Engineer, General Electric Company, West Lynn, Mass. 1912

THORKELSON, H. J., Business Manager, University of Wisconsin, Madison, Wis. 1909

THORNBURG, C. L., Professor of Mathematics and Astronomy, Lehigh University, South Bethlehem, Pa....................... 1894

Thornton, W. M., Professor of Applied Mathematics and Dean of the Department of Engineering, University of Virginia, University, Va. 1916

Thoroughgood, R. W., Professor of Civil Engineering, University of Florida, Gainesville, Fla. 1913

Thurber, Chas. H., Editor, Ginn & Co., 15 Ashburton Place, Boston, Mass. 1914

Tibbetts, F. H., Civil Engineer, Alaska Commercial Bldg., San Francisco, Calif. 1908

Tilden, C. J., Professor of Civil Engineering, The Johns Hopkins University, Baltimore, Md. 1913

Timbie, W. H., Head of Applied Science Dept., Wentworth Institute, Boston, Mass. 1908

Titsworth, A. A., Professor of Civil Engineering, Dean of Engineering, Rutgers College, New Brunswick, N. J. 1903

Tivey, J. P., Engineer, Australian General Electric Co., Mazda House, Wentworth Ave., Sydney, Australia 1912

Todd, M. E., Instructor in Electricity, William Hood Dunwoody Institute, Minneapolis, Minn. 1913

Tompkins, V. D., Supt. of Electrical Shops, Robert College, Constantinople, Turkey 1915

Tonsor, Charles A., Jr., Assistant Professor of English, School of Applied Science, New York University, New York, N. Y. .. 1918

Topping, A. N., Professor of Electrical Engineering, Purdue University, LaFayette, Ind. 1910

Touceda, E. A., Professor of Metallurgy, Rensselaer Polytechnic Institute, Troy, N. Y. 1907

Tower, C. H., Engineer, The Motor Devices Co., 1033 Williamson Bldg., Cleveland, Ohio 1911

Towle, W. M., Professor of Industrial Engineering, Clarkson College of Technology, Potsdam, N. Y. 1895

Tracy, J. C., Professor of Civil Engineering, Yale University, New Haven, Conn. 1907

Traill, J. J., Lecturer on Hydraulics, University of Toronto, Toronto, Ont., Canada 1912

Trinks, W., Professor and Head of Department of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1917

Trowbridge, D. S., Assistant Professor of Civil Engineering, New York University, New York, N. Y. 1917

Trummell, M. F., Waukegan, Ill. 1915

Tucker, E. N., Instructor in Mathematics, Virginia Episcopal School, Lynchburg, Va. 1915

Tucker, J. I., Professor and Director of the School of Civil Engineering, University of Oklahoma, Norman, Okla. 1912

Turley, O. J., Consulting Civil and Irrigation Engineer, Sante Fe, New Mexico 1912

Turnbull, W. D., Assistant Professor of Engineering Drawing, The Ohio State University, Columbus, O. 1917

Turneaure, F. E., Dean of the College of Engineering, University of Wisconsin, Madison, Wis. 1894

Turner, C. A. P., Engineer, 2675 Lake of Isles Blvd., Minneapolis, Minn. 1913

Turner, D. L., Chief Engineer, Public Service Commission for the First District, 606 W. 116th St., New York, N. Y. 1898

Turner, W. P., Professor of Practical Mechanics, Purdue University LaFayette, Ind. 1900

Turner, Wm. S., Consulting Engineer, 1006 Spalding Bldg., Portland, Ore. 1911

Tyler, H. G., Assistant Professor of Mechanical Engineering, New York University, University Heights, New York, N. Y. 1915

Tyler, H. W., Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1894

Tyrrell, H. G., Chief Engineer and Manager, Tyrrell Engineering Co., Detroit, Mich. 1912

Upson, W. L., Associate Professor of Electrical Engineering, Union University, Schenectady, N. Y. 1910

Van Buskirk, H. C., Professor of Mathematics, Throop College of Technology, Pasadena, Calif. 1911

Vanderbeek, H. A., Dean and Professor of Civil Engineering, Government Institute of Technology, Shanghai, China 1915

Van Hagan, L. F., Associate Professor of Railway Engineering, University of Wisconsin, Madison, Wis. 1912

Van Ness, L. G., Vice-President and General Manager, Merchants' Power Co., Memphis, Tenn. 1907

Van Ornum, J. L., Professor of Civil Engineering, Washington University, St. Louis, Mo. 1895

Vaughan, L. L., Assistant Professor of Experimental Engineering, North Carolina State College of Agriculture and Engineering, West Raleigh, N. C. 1912

Veal, C. B., Assistant Inspection Engineer, Curtis Aeroplane & Motor Corporation, Buffalo, N. Y. 1910

Vedder, H. K., Professor of Civil Engineering, Michigan Agricultural College, East Lansing, Mich. 1894

Vedder, J. N., Professor of Thermodynamics, Union College, Schenectady, N. Y. 1910

von Ende, C. L., Professor of Chemistry, University of Idaho, Moscow, Idaho 1911

VON RITTER, ALEX, The Commonwealth Edison Co., N. W. Power Station, Chicago, Ill. 1913

VOSE, F. H., Professor of Mechanical Engineering, in charge of the department, Case School of Applied Science, Cleveland, O. 1907

VOSKAMP, JOHN A., Instructor in Civil Engineering, New York University, University Heights, N. Y. 1918

VOTEY, J. W., Professor of Civil Engineering and Dean of the College of Engineering, University of Vermont, Burlington, Vt. 1902

WADDELL, J. A. L., Consulting Bridge Engineer, Waddell & Son, 800 Graphic Arts Bldg., Kansas City, Mo. 1893

WADSWORTH, F. L. O., Consulting and Advisory Engineer, Oliver Bldg., Pittsburgh, Pa. 1911

WADSWORTH, J. E., Division Engineer, American Bridge Co., 22 Morsemere Place, Yonkers, N. Y. 1895

WADSWORTH, M. E., Emeritus Dean and Professor of Mining Geology and Curator of the Mineralogical and Petrographical Collections, School of Mines, University of Pittsburgh, Pittsburgh, Pa. 1895

WAGNER, F. C., Professor of Mechanical and Electrical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1911

WAGNER, S. T., Chief Engineer, The Philadelphia and Reading Railway Co., Philadelphia, Pa. 1911

WAIT, J. C., Attorney and Counsellor-at-law, Engineering Jurisprudence, Woolworth Bldg., 233 Broadway, New York, N. Y. 1907

WAITE, E. B., Practicing Engineer, Millbury, Mass. 1914

WALDO, C. A., Thayer Professor of Mathematics and Applied Mechanics, Washington University, St. Louis, Mo. 1897

WALDO, W. G., Instructor in Mathematics and Applied Mechanics, Vanderbilt University, Nashville, Tenn. 1917

WALES, R. L., Professor of Mechanical Engineering and Dean of Engineering Depts., Rhode Island State College, Kingston, R. I. 1914

WALKER, AMASA, Manager of Educational Dept., Longmans, Green & Co., 449 Fourth Ave., New York, N. Y. 1914

WALKER, CHAS. L., Assistant Professor of Sanitary Engineering, College of Civil Engineering, Cornell University, Ithaca, N. Y. 1910

WALKER, E. D., Professor of Hydraulic and Sanitary Engineering, Pennsylvania State College, State College, Pa 1895

WALKER, E. S., Assistant Professor of Mechanical Engineering, University of Florida, Gainesville, Fla. 1910

WALKER, P. F., Dean of the School of Engineering, University of Kansas, Lawrence, Kans. 1907

WALKER, WM. H., Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1912

WALLER, O. L., Vice-President and Professor of Mathematics and Civil Engineering, State College of Washington, Pullman, Wash. 1911

WALTER, J. E., Professor of Mechanical Engineering, Highland Park College, Des Moines, Ia. 1915

WARD, SAMUEL, Instructor in Civil Engineering, Case School of Applied Science, Cleveland, O. 1917

WARD, WALTER G., Instructor in Architecture, North Dakota Agricultural College, Agricultural College, N. D. 1918

WARNER, F. M., Assistant Professor of Engineering Drawing, University of Washington, Seattle, Wash. 1917

WATERMAN, E. L., Associate Professor of Sanitary Engineering, Pennsylvania State College, State College, Pa. 1907

WATERMAN, I. F., Instructor in Civil Engineering, John B. Stetson University, De Land, Fla. 1916

WATERS, E. O., Instructor in Machine Design, Sheffield Scientific School, Yale University, New Haven, Conn. 1914

WATSON, J. W., Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1910

WATTS, C. W., Professor of Mathematics, The Virginia Military Institute, Lexington, Va. 1911

WEAVER, L. H. A., 129 West 83d St., New York, N. Y. 1914

WEAVER, WARREN, Assistant Professor of Mathematics, Throop College of Technology, Pasadena, Calif. 1918

WEBB, H. E., Head of the Department of Mathematics, Central Commercial and Manual Training High School, Newark, N. J. 1912

WEBBER, R. I., Head of Department of Drawing and Architectural Engineering, Pennsylvania State College, State College, Pa. .. 1907

WEBER, JOHN, Associate Professor of Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914

WEINBACH, M. P., Assistant Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1915

WEISS, CAMILLO, Instructor in Structural Engineering, University of Illinois, Urbana, Ill. 1917

WENDELL, G. V., Professor of Physics, Columbia University, New York, N. Y. 1900

WENDT, W. B., Assistant Professor of Applied Mechanics, Kansas State Agricultural College, Manhattan, Kans. 1908

WENRICH, C. N., Professor of Physics, University of Pittsburgh, Pittsburgh, Pa. 1914

WERNECKE, CHAUNCY, Instructor in Mechanics and Reinforced Concrete Construction, University of Washington, Seattle, Wash. 1912

Weston, Edw., President, The Weston Electrical Instrument Co., Waverly Park, Newark, N. J.	**1911**
Wharton, J. Norman, Assistant Professor of English, College of Applied Science, Syracuse University, Syracuse, N. Y.	1918
Wheatley, G. S., Assistant Steam Engineer, Cambria Steel Co., Johnstown, Pa.	1914
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Whipple, G. C., Professor of Sanitary Engineering, Harvard University, 6 Berkeley Place, Cambridge, Mass.	**1896**
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White, E. C., Professor of Civil Engineering, New Mexico School of Mines, Socorro, N. Mex.	**1913**
White, J. M., Professor of Architectural Engineering and Supervising Architect, University of Illinois, Urbana, Ill.	**1900**
Whitehead, J. B., Professor of Electrical Engineering, The Johns Hopkins University, Baltimore, Md.	1913
Whitehead, L. W., Instructor in Civil Engineering, The Pennsylvania State College, State College, Pa.	1918
Whitmore, R. D., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass.	1917
Wickenden, Wm. E., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass.	**1912**
Wigley, W. R., Assistant Engineer, Aetna Explosives Co., 120 Broadway, New York, N. Y.	1915
Wiley, W. O., Publisher of Scientific Books, Treasurer, John Wiley & Sons, Inc., New York, N. Y.	1904
Williams, C. C., Professor of Railway Engineering, University of Kansas, Lawrence, Kans.	**1909**
Williams, F. B., Professor of Mathematics, Clark College, Worcester, Mass.	**1901**
Williams, O. E., Assistant Professor of Engineering Drawing, The Ohio State University, Columbus, O.	**1910**
Williams, S. N., Professor Emeritus of Civil and Sanitary Engineering, Cornell College, 734 N. Fairoaks Ave., Oak Park, Ill.	**1893**
Williams, W. S., Associate Professor of Topographical Engineering, University of Missouri, Columbia, Mo.	**1918**
Willis, A. J., Professor of Civil Engineering, South Dakota State College, Brookings, S. D.	**1912**
Williston, Arthur L., Principal, Wentworth Institute, Boston, Mass.	**1897**
Wills, C. F., Director, Arizona State Bureau of Mines, Tucson, Ariz.	1917

WILLSON, F. G., Head of Dept. of Applied Electricity, Wentworth Institute, Boston, Mass. 1912

WILLSON, F. N., Professor of Graphics, Princeton University, Princeton, N. J. 1913

WILMORE, J. J., Dean, School of Engineering, and Professor of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1894

WILSON, A. M., Professor of Electrical Engineering, University of Cincinnati, Cincinnati, O. 1907

WILSON, GEO. S., Associate Professor of Mechanical Engineering, University of Washington, Seattle, Wash. 1912

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WILSON, W. L., Professor of Railroad Engineering, Lehigh University, South Bethlehem, Pa. 1909

WILSON, WILBUR M., Assistant Professor of Structural Engineering, University of Illinois, Urbana, Ill. 1914

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WINSLOW, A. E., Professor of Civil Engineering, Norwich University, Northfield, Vt. 1914

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WITHAM, R. L., Electrical Engineer, Industrial Division, Westinghouse E. & M. Co., East Pittsburgh, Pa. 1914

WITHEY, M. O., Associate Professor of Mechanics, University of Wisconsin, Madison, Wis. 1910

WITHROW, JAMES R., Professor of Chemistry, Ohio State University, Columbus, O. 1907

WITTIG, GUSTAV, Assistant Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 1910

WOHLENBERG, W. J., Assistant Professor of Mechanical Engineering, University of Montana, Bozeman, Mont. 1917

WOLF, HARRY J., Professor of Mining, Colorado School of Mines, Golden, Col. 1914

WOLFE, W. S., Instructor in Architectural Engineering, University of Illinois, Urbana, Ill. 1916

WOLFEL, PAUL L., Chief Engineer, McClintic-Marshall Co., Pittsburgh, Pa. 1910

WOOD, A. J., Associate Professor of Railway Mechanical Engineering, Pennsylvania State College, State College, Pa. 1898

Wood, E. H., Professor of Mechanics of Engineering, Cornell University, Ithaca, N. Y. 1910

Woodman, J. E., Professor of Geology and Director of Geological Museum, New York University, New York, N. Y. 1912

Woodrow, Jay W., Assistant Professor of Physics, University of Colorado, Boulder, Colo. 1918

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Woodward, R. S., President, Carnegie Institution of Washington, Washington, D. C. 1893

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Wright, D. M., Sec'y and Treasurer, The Henry & Wright Mfg. Co., 52 Irving St., Hartford, Conn. 1914

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Zeller, J. W., Duval High School, Jacksonville, Fla. 1912

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Zimmerman, O. B., Advisory Engineer to Sales and Manufacturing in Europe, 11–13 Rue d'Arenberg, Brussels, Belgium 1902

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Florida	7	New York	168	Canada	32
Georgia	8	North Carolina	13	Chile	4
Idaho	6	North Dakota	7	China	6
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Iowa	36	Oregon	8	Hawaii Territory.	1
Kansas	46	Pennsylvania	169	Hungary	1
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Sheppard, H. S.
Shuster, J. W.
Slichter, W. I.
Smith, Arthur Bessey.
Smith, H. B.
Sorensen, R. W.
Springer, F. W.
Staples, E. I.
Steinmetz, C. P.
Stelzner, W. B.
Stevens, A. C.
Stevens, J. Floyd.
Stillwell, L. B.
Stockwell, F. C.
Stone, Chas. W.
Straw, J. B.
Sturges, T. L., Jr.
Tanzer, E. Dean.
Temple, W. E. S.
Thaler, J. A.
Thomas, Geo. B.
Thompson, Frank F.
Thomson, R. D.
Timbie, W. H.
Tivey, J. P.
Todd, M. E.
Tompkins, V. D.
Topping, A. N.
Trummell, M. F.
Turner, Wm. S.
Upson, W. L.
Wadsworth, F. L. O.
Watson, J. W.
Weinbach, M. P.
Whitehead, J. B.
Wickenden, Wm. E.
Willson, F. G.
Wilson, A. M.
Wilson, John F.
Witham, R. L.
Wittig, Gustav.
Wooster, L. F.
Wright, C. A.
Wurts, A. J.
Wyman, F. T.

GEOLOGY AND METALLURGY

nderson, R. J.
ston, James.
emorest, J. D.
alpin, S. L.
eorge, R. D.
Hofman, H. O.
Linville, C. P.
McCaffery, Richard S.
Ray, H. C.
Smith, J. E.
Touceda, E. A.
Wadsworth, M. E.
Woodman, J. E.

INDUSTRIAL ENGINEERING

iemer, Hugo.
eller, J. O.
Kimball, D. S.
Myers, Curtis C.

LANGUAGE

ydelotte, Frank.
aebenroth, A. C.
rown, Katharine D.
cDonald, P. B.
acarthur, J. R.
elson, J. R.
Newman, C. M.
Park, C. W.
Raymond, F. N.
Searson, J. W.
Seaver, H. L.
Sypherd, W. O.
Telleen, J. M.
Tonsor, C. A., Jr.
Wharton, J. Norman.
Wright, A. S.

MACHINE DESIGN AND DRAWING

ller, A. A.
len, F. G.
bbitt, Arthur B.
rard, S. J.
yans, W. R.
rroll, H. H.
app, W. H.
mstock, F. M.
nsoliver, Earl L.
ppersmith, C. W.
vis, Jas. C.
Schweinitz, P. B.
nham, Heber.
nmore, G. B.
lis, W. T.
ch, F. R.
ench, Thos. E.
y, H. P.
lan, M. T.
rman, F. DeR.
ulding, Herbert J.
etzinger, C. A.
rper, A. C.
Harper, C. H.
Hawes, J. H.
Hay, E. D.
Henshall, P. P.
Higbee, F. G.
Hood, G. J.
Howe, L. B.
Jordan, H. H.
Kenison, Ervin.
Kennedy, F. L.
Keown, R. McA.
Kirby, R. S.
Kirchner, W. H.
Knapp, E. R.
Lagergren, J. T.
Langille, H. B.
LeTellier, L. S.
Logan, D. M.
Mack, J. G. D.
Mease, J. A.
Meiklejohn, Robert.
Millar, A. V.
Newton, Guy D.
Norman, Carl A.
Orth, H. D.
Owens, R. H.
Pearce, C. E.
Porter, F. M.
Price, C. B.
Rondinella, L. F.
Slaymaker, P. K.
Smith, A. L.
Steward, R. K.
Strong, Albert J.
Svensen, C. L.
Swett, G. W.
Thomas, Chas. W.
Towle, W. M.
Turnbull, W. D.
Warner, F. M.
Waters, E. O.
Whitmore, R. D.
Williams, O. E.
Willson, F. N.

MATHEMATICS

drews, W. H.
ton, C. H.
Ade, H. T. R.
nbridge, G. H.
ry, W. J.
le, J. S.
sefield, S. E.
wne, E. T.
tterfield, A. D.
Cney, G. A.
Cb, H. E.
Cnstock, C. E.
Cbin, C. E.
Cckett, Chas. W.
Cmings, H. N.
aker, H. H.
ong, Ira M.
bs, F. E.
and, J. J.
igherty, H. R.
ondson, T. W.
ns, H. B.
e, H. B.
Focke, T. M.
Foraker, F. A.
Frear, J. B.
Fulton, Wm. L.
Garrett, L. E.
Grant, E. D.
Gunther, Chas. O.
Hagerty, C. T.
Haigler, Chas. E.
Hanna, U. S.
Harter, G. A.
Haseman, Charles.
Haskell, M. W.
Hedrick, E. R.
Holder, F. J.
Hoskins, L. M.
Huntington, E. V.
Lambert, P. A.
Little, G. T.
Luby, Wm. A.
MacDonald, S. L.
Mathews, R. M.
Miser, W. L.
Moore, F. C.
Moritz, R. E.
Murray, D. A.
Northcott, J. A.
Oglesby, E. J.
O'Shaughnessy, Louis.
Passano, L. M.
Pehrson, E. W.
Phalen, Harold.
Plant, L. C.
Porter, H. E.
Remick, B. L.
Richardson, M. R.
Ridout, John.
Risley, W. J.
Robertson, J. E.
Root, R. E.
Running, Theo. R.
Scarborough, J. B.
Slichter, C. S.
Smith, P. F.
Sperry, C. S.
Stetson, J. M.

Swartzel, K. D.
Tallman, Wm. D.
Taylor, Wm. E.
Thomas, C. F.
Thomas, Evan.
Thomas, R. P.
Thornburg, C. L.
Tucker, E. N.
Tyler, H. W.
VanBuskirk, H. C.
Waldo, C. A.
Watts, C. W.
Weaver, Warren.
Webb, H. E.
White, A. E.
Williams, F. B.
Ziwet, Alexander.

MECHANICAL ENGINEERING

Adams, W. H.
Adamson, K. F.
Anderson, A. H.
Anderson, William.
Appleton, W. D.
Arkley, L. M.
Baender, F. G.
Bark, Elmer.
Barnard, W. N.
Barraclough, S. H.
Bates, J. T.
Bauer, F. S.
Benedict, H. G.
Berger, F. A.
Billmyer, Carroll D.
Bird, Wm. W.
Blessing, G. F.
Bliss, C. P.
Bowerman, M. R.
Boyer, F. Q.
Bray, H. C. C.
Breckenridge, L. P.
Brown, A. I.
Bullock, W. E.
Burpee, F. E.
Bursley, J. A.
Callan, John G.
Carlson, W. W.
Carpenter, Randle C.
Chapman, L. B.
Charavay, M. A.
Chase, C. H.
Christensen, Geo. L.
Christian, J. W.
Church, E. F., Jr.
Cleghorn, M. P.
Coates, Arthur B.
Cook, Robertson.
Cooke, M. L.
Corp, C. I.
Crain, L. D.
Davidson, M. W.
Dearborn, C. S.
Denn, H. H.
Dent, J. A.
DePuy, C. E.
DeTurk, J. A.
Dickerson, H. S.
Diederichs, Herman.
Dowell, Dawson.
Dreyer, C. F.
Dunkin, W. V.
Durand, W. F.
Eddison, Wm. B.
Edwards, W. W.
Ehlers, H. E.
Elliott, B. G.
Emswiler, J. E.
Endsley, L. E.
Ennis, W. D.
Eyre, T. T.
Faig, J. T.
Fermier, E. J.
Fernald, R. H.
Fessenden, E. A.
Flather, J. J.
Folk, J. T.
Frank, E. D. A.
Freeman, P. J.
Fry, Lawford H.
Garver, J. D.
Gates, A. O.
Goodenough, G. A.
Greene, A. M., Jr.
Gregory, W. B.
Griswold, R. G.
Grumbein, J. B.
Grundhoeffer, E. F.
Gwiazdowski, A. S.
Hall, James.
Hall, W. H.
Hallock, J. W.
Halsey, F. A.
Halsey, W. D.
Hammer, M. R.
Hancock, Chas.
Haney, J. W.
Heck, Robert C. H.
Helman, M. P.
Henley, W. W.
Hibbard, H. Wade.
Hixon, C. R.
Hoefer, E. G.
Hoerning, Carlos.
Hoexter, S. J.
Hofmann, G. A.
Hollis, Ira N.
Hood, O. P.
Hunter, J. A.
Jablow, Charles.
Jacobus, D. S.
Jones, E. C.
Judd, Horace.
Kavanaugh, W. H.
Kenerson, W. H.
Kent, Wm.
Kerr, E. W.
Kiefer, P. J.
King, R. S.
Kingsbury, Albert.
Klein, A. W.
Kunze, E. J.
Lapham, J. S.
Larson, G. L.
LeConte, J. N.
Lekberg, C. H.
Leutwiler, O. A.
Light, J. J.
Lockwood, E. H.
Lucke, C. E.
Ludy, L. V.
McKergow, C. M.
MacNaughton, Edgar.
Magruder, Wm. T.
Main, C. T.
Mallory, W. F.
Marks, L. S.
Marquis, F. W.
Martenis, J. Van S.
Martin, W. H.
Martinson, C. G.
Mason, A. J.
Matthews, Robertson.
Meeker, W. H.
Mickle, Frank A.
Moody, L. F.
Morse, J. L.
Moseley, A. W.
Moss, S. A.
Moyle, M. W.
Muhfeld, J. E.
Munn, D. W.
Munro, A. R.
Munro, G. W.
Norton, A. E.
Nottingham, A. R.
Ohle, E. L.
O'Neill, J. F.
Olson, O. A.
Park, C. F.
Parkin, J. H.
Perry, W. H.
Philbrick, H. S.
Poole, Cecil P.
Porter, R. H.
Pound, J. H.
Prentice, D. B.
Pryor, F. L.
Raber, B. F.
Radebaugh, G. H.
Rasmusen, J. E.
Richardson, G. R.
Robinson, Edw.
Robinson, M. B.
Roe, J. W.
Rogers, Ralph.
Rowley, F. B.
Sadler, H. C.
Sanders, W. H.
Satterfield, H. E.
Schmidt, E. C.
Seaton, L. F.
Seward, H. L.
Shattuck, E. L.
Shipley, S. C.
Shoop, C. F.
Shutt, J. C.
Sibley, F. H.
Simmering, S. L.
Sluss, A. H.
Smallwood, Julian.
Smith, E. B.
Smith, Harry E.
Solberg, H. C.
Stanford, J. V.
Starkey, L. C.
Streeter, R. L.
Styer, Charles A.
Sullivan, Geo. L.

Sweetser, W. J.
Taylor, L. B.
Thomas, C. C.
Trinks, W.
Tyler, H. G.
Vaughan, L. L.
Vedder, J. N.
Von Ritter, Alex.
Vose, F. H.
Wagner, F. C.
Waite, E. B.
Wales, R. L.
Walker, E. S.
Walter, J. E.
Weaver, L. H. A.
Weber, John.
Wheatley, G. S.
Wigley, W. R.
Wilmore, J. J.
Wilson, Geo. S.
Wing, S. R.
Winter, J. W.
Wohlenberg, W. H.
Wood, A. J.
Young, G. A.
Zowski-Zwierzchowski, S.J.

MECHANICS AND MATERIALS

Basquin, O. H.
Becker, A. J.
Blackburn, H. W.
Boomsliter, G. P.
Boyd, J. E.
Brooke, W. E.
Brooks, J. Ansel.
Brown, F. L.
Burnside, C. H.
Chatburn, G. R.
Church, I. P.
Cornell, W. R.
Danforth, R. H.
Defoe, L. M.
Deimel, R. F.
Draffin, J. O.
Dukes, R. G.
Emory, F. L.
Enger, M. L.
Ensign, N. E.
Fleming, V. R.
Fuller, C. E.
George, S. G.
Hayward, H. W.
Herschel, W. H.
Holman, W. F.
Hotchkiss, H. J.
Houghton, C. E.
Hutchins, R. E.
Johnston, W. A.
King, Carl.
Lawrance, C. H.
McAlister, E. H.
McGowan, John.
Mathewson, J. S.
Maurer, E. R.
Moore, H. F.
Nelson, J. H.
Newkirk, B. L.
Olmsted, Chas. T.
Patterson, T. S.
Paul, C. E.
Poorman, A. P.
Porter, Chas. T.
Putnam, Wm. J.
Riggs, N. C.
Robert, J. H.
Roys, F. W.
Seaton, R. A.
Seely, F. B.
Stevens, F. H.
Talbot, Arthur N.
Taylor, I. I.
Thompson, G. S.
Thornton, W. M.
Wendt, W. B.
Withey, M. O.
Wood, E. H.
Woodward, S. M.

MINING ENGINEERING

Black, R. M.
Boyle, A. C., Jr.
Chedsey, W. R.
Cobb, Collier.
Comstock, E. H.
Daniels, Jos.
Denton, F. W.
Dyer, F. C.
Hodson, L. C.
Holbrook, E. A.
Kidd, J. W.
McClelland, J. F.
Munroe, H. S.
Nold, H. E.
Porter, J. B.
Probert, F. H.
Roberts, Milnor.
Smyth, H. L.
Sperr, F. W.
Stoek, H. H.
Terrill, A. C.
Thomson, Francis A.
Wolf, Harry J.
Young, C. M.

PHYSICS

Allee, W. G.
Angel, Wm. P.
Ball, Albert.
Bellis, A. E.
Bevan, W. A.
Blake, Fred C.
Brown, S. L.
Charles, R. L.
Cole, Alfred D.
Cooper, F. L.
Dadourian, H. M.
Douglas, J. F. H.
Duffy, C. F.
Dysart, P. M.
Fisher, James.
Franklin, W. S.
Gilmore, L. H.
Graham, P. H.
Grondahl, L. O.
Ham, Wm. R.
Hamilton, J. O.
Hedrick, Wm. A.
Hitchcock, Geo. G.
Hower, H. S.
Hoxton, L. G.
Kinsley, Carl.
LePage, Clifford B.
Lester, O. C.
Lodge, W. L.
MacNutt, Barry.
Mallory, Francis.
Mann, C. R.
Marvin, H. H.
Mathews, H. B.
Miller, Dayton C.
Molby, F. A.
Norton, C. L.
Nyswander, R. E.
Ossa, Gaston.
Perry, Wm. S.
Person, Fred G.
Plagge, H. J.
Prine, C. W.
Porter, R. A.
Randolph, Oscar A.
Richtmyer, F. K.
Silvey, O. W.
Snader, David L.
Snow, O. L.
Spinney, L. B.
Stevens, W. LeConte.
Stewart, G. W.
Stewart, O. M.
Wendell, G. V.
Wenrich, C. N.
Wheeler, L. P.
Woodrow, Jay W.

SANITARY ENGINEERING

Case, George W.
Dix, L. E.
Dunlap, J. H.
Eno, F. H.
Hawley, J. B.
Hering, Rudolph.

Hoad, W. C.
Jones, G. R.
Knowles, Morris.
Long, J. J.
Lund, Jacob.
Mackenzie, C. J.
Mead, D. W.
Naidu, K. S.
Nichols, Chas. S.
Osborn, G. M.
Rogers, C. E.
Root, J. E.
Saville, Thorndike.
Walker, Chas. L.
Walker, E. D.
Waterman, E. L.
Whipple, G. C.

SHOP AND MECHANIC ARTS

Acker, M. W.
Applin, Samuel.
Benedict, B. W.
Bloemker, Chas. W.
Davis, E. S.
Eaton, J. S.
Ellis, Frederick.
Goddard, A. L.
Hall, P. R.
Hayes, Thornton.
Hendry, W. S.
Herget, A. M.
Holmes, Paul E.
Johnson, E. A.
Jones, F. E.
Kane, S. M.
Kinsey, A. S.
Knight, W. A.
Krewson, R. H.
Lynch, D. E.
Morris, J. J.
Mounce, J. L.
Newhall, A. B.
Noble, H. P.
Perry, C. F.
Richards, Wm. H.
Rodgers, L. J.
Sanborn, F. E.
Smith, R. J.
Steele, J. N.
Stewart, C.E.
Turner, W. P.

MISCELLANEOUS

Arnett, L. D.
Avram, W. H.
Coster, E. L.
Creighton, E. E. F.
Domonoske, A. B.
Duff, C. M.
Fetter, Frank A.
Hallsted, J. C.
Hastings, H. B.
Read, B. K.
Richards, T. E.
Selby, L. B.
Snavely, T. R.
Tower, C. H.
Turner, C. A. P.

SUMMARY BY OCCUPATIONS.

Administration Officers:	*A*—College and University	145
	B—Industrial	90
Architecture		14
Agricultural Engineering		10
Chemistry		23
Civil Engineering		318
Electrical Engineering		230
Geology and Metallurgy		13
Industrial Engineering		4
Language		16
Machine Design and Drawing		67
Mathematics		86
Mechanical Engineering		215
Mechanics and Materials		59
Mining Engineering		24
Physics		57
Sanitary Engineering		23
Shop and Mechanic Arts		32
Miscellaneous		15
		1441

INSTITUTIONS REPRESENTED.

	1916	1917	1918
Agnes Scott College, Decatur, Ill.	0	1	1
Akron, Municipal University of, Akron, O.	3	2	3
Alabama Polytechnic Institute, Auburn, Ala.	9	9	6
Alabama, University of, University, Ala.	4	4	2
Alberta, University of, Edmonton South, Alta, Canada	2	2	2
Alexander Hamilton Institute, New York, N. Y.	1	1	1
Arizona, University of, Tucson, Ariz.	4	4	3
Arkansas, University of, Fayetteville, Ark.	5	5	6
Armour Institute of Technology, Chicago, Ill.	7	7	7
Berea College, Berea, Ky.	1	1	1
Boston Industrial School for Boys, Boston, Mass.	2	1	1
Bradley Polytechnic Institute, Peoria, Ill.	2	1	1
Brooklyn Manual Training H. S., Brooklyn, N. Y.	1	1	1
Brooklyn Polytechnic Institute, Brooklyn, N. Y.	9	10	9
Brown University, Providence, R. I.	8	6	7
Bucknell University, Lewisburg, Pa.	2	2	2
California, University of, Berkeley, Cal.	7	9	9
Carnegie Institution, Washington, D. C.	1	1	1
Carnegie Institute of Technology, Pittsburgh, Pa.	14	15	15
Case School of Applied Science, Cleveland, O.	21	21	18
Casino Technical Night School, East Pittsburgh, Pa.	1	1	1
Catholic University of America, Washington, D. C.	0	1	1
Central Commercial and M. T. H. S., Newark, N. J.	1	1	1
Central High School, Washington, D. C.	0	1	1
Central Continuation School	1	1	1
Chestnut Hill Academy, Chestnut Hill, Pa.	1	1	1
Chicago, University of, Chicago, Ill.	2	2	3
Chicago Central Station Institute, Chicago, Ill.	1	1	1
Cincinnati, University of, Cincinnati, O.	11	9	8
Citadel, The, Charleston, S. C.	2	2	2
Clark College, Worcester, Mass.	1	1	1
Clarkson College of Technology, Potsdam, N. Y.	4	3	3
Clemson A. & M. College, Clemson College, S. C.	5	5	4
Cleveland Technical H. S., Cleveland, O.	3	3	3
College of the City of N. Y., New York, N. Y.	1	1	1
Colorado College, Colorado Springs, Colo.	2	2	3
Colorado School of Mines, Golden, Colo.	3	4	3
Colorado State Agri. College, Fort Collins, Colo.	5	5	7
Colorado, University of, Boulder, Colo.	25	24	28

College of the City of New York, New York, N. Y.	1	1	1
College of the Pacific, San Jose, Calif.	0	1	1
Columbia University, New York, N. Y.	16	11	9
Cooper Union, New York, N. Y.	6	6	6
Cornell College, Mt. Vernon, Ia.	1	1	1
Cornell University, Ithaca, N. Y.	26	24	19
Dartmouth College, Hanover, N. H.	5	4	4
David Rankin, Jr. Sch., St. Louis, Mo.	2	1	1
Delaware College, Newark, Del.	5	5	5
Denver, University of, Denver, Colo.	1	1	1
Dickinson H. S., Jersey City, N. J.	3	2	1
Dorchester H. S., Dorchester Center, Mass.	1	1	1
Drexel Institute, Philadelphia, Pa.	11	11	11
Duval High School, Jacksonville, Fla.	1	1	1
Ecole Polytechnique de Montreal, Montreal, Canada	0	0	1
Escola de Engenharia, Porto Alegre, Brazil	1	1	1
Florida, University of, Gainesville, Fla.	5	5	5
Franklin Institute, Philadelphia, Pa.	1	1	1
Franklin Union, Boston, Mass.	4	4	4
George Washington University, Washington, D. C.	3	3	4
Georgia School of Technology, Atlanta, Ga.	2	3	6
Girard College, Philadelphia, Pa.	1	1	1
Government Institute of Technology, Shanghai, China	3	3	3
Harvard University, Cambridge, Mass.	17	15	7
Haverford College, Haverford, Pa.	1	1	1
Hebrew Technical Institute, New York, N. Y.	1	1	1
High Schools, Lakewood, O.	0	0	1
Highland Park College, Des Moines, Ia.	3	3	2
Idaho, University of, Moscow, Ida.	4	3	6
Illinois, University of, Urbana, Ill.	47	46	45
Indiana University, Bloomington, Ind.	2	2	2
Instituto Technico Professional, Porto Alegre, Brazil	2	1	1
International Correspondence Schools, Scranton, Pa.	3	2	2
Iowa State College, Ames, Ia.	29	28	29
Iowa, State University of, Iowa City, Ia.	7	7	7
James Millikin University, Decatur, Ill.	1	1	1
Johns Hopkins University, The, Baltimore, Md.	5	6	6
John B. Stetson University, De Land, Fla.	1	1	1
Kansas City M. T. H. S., Kansas City, Mo.	1	1	1
Kansas City Polytechnic Inst., Kansas City, Mo.	1	1	1
Kansas State Agri. College, Manhattan, Kans.	32	30	32
Kansas, University of, Lawrence, Kans.	16	18	17
Kentucky, State University of, Lexington, Ky.	3	3	4
Lafayette College, Easton, Pa.	5	5	4

Lehigh University, Bethlehem, Pa.	14	13	13
Leland Stanford Jr. Univ., Stanford Univ., Calif.	4	5	4
Lewis Institute, Chicago, Ill.	3	3	3
Louisiana Industrial Institute, Ruston, La.	3	2	4
Louisiana State University, Baton Rouge, La.	3	3	3
McGill University, Montreal, Canada	5	5	5
McKinley High School, St. Louis, Mo.	1	1	1
Maine, University of, Orono, Me.	8	9	8
Manitoba, University of, Winnipeg, Man.	3	3	2
Marquette University, Milwaukee, Wis.	1	1	2
Maryland State College of Agri., College Park, Md.	0	1	1
Massachusetts Agri. College, Amherst, Mass.	1	1	1
Massachusetts Inst. of Tech., Cambridge, Mass.	33	40	40
Mechanics Institute, Rochester, N. Y.	3	3	2
Miami University, Oxford, O.	1	1	1
Michigan Agri. College, East Lansing, Mich.	10	9	7
Michigan College of Mines, Houghton, Mich.	10	9	9
Michigan, University of, Ann Arbor, Mich.	28	25	24
Milwaukee Public Schools, Milwaukee, Wis.	0	1	1
Milwaukee, School of Engineering of, Milwaukee, Wis.	0	1	1
Minnesota, University of, Minneapolis, Minn.	28	27	24
Mississippi, A. & M. College, Agricultural College, Miss.	8	7	4
Mississippi, University of, University, Miss.	2	3	4
Missouri School of Mines, Rolla, Mo.	4	5	5
Missouri, University of, Columbia, Mo.	15	15	13
Montana Agri. College, Bozeman, Mont.	5	4	6
Nebraska, University of, Lincoln, Nebr.	14	14	13
Nevada, University of, Reno, Nev.	3	3	3
New Hampshire College, Durham, N. H.	4	4	4
New Mexico Coll. of A. & M. Arts, State College, N. M.	3	4	4
New Mexico School of Mines, Socorro, N. Mex.	0	1	1
New York Military College, Cornwall-on-Hudson, N. Y.	1	1	1
New York University, New York, N. Y.	8	9	12
North Carolina State College of A. & E., West Raleigh, N. C.	5	5	6
North Carolina, University of, Chapel Hill, N. C.	8	6	6
North Dakota Agri. College, Agricultural College, N. D.	2	1	1
North Dakota, University of, University, N. D.	5	5	5
Northeastern College, Boston, Mass.	0	0	1
Northwestern University, Evanston, Ill.	8	6	8
Notre Dame, University of, Notre Dame, Ind.	1	1	
Norwegian Technical University, Trondhjem, Norway	1	1	1
Norwich University, Northfield, Vt.	1	1	3
Nova Scotia Technical College, Halifax, N. S.	2	2	2

Ohio Northern University, Ada, O.	2	2	3
Ohio State University, Columbus, O.	26	30	32
Oklahoma A. & M. College, Stillwater, Okla.	5	5	4
Oklahoma, University of, Norman, Okla.	4	5	8
Oregon Agri. College, Corvallis, Ore.	4	5	5
Oregon, University of, Eugene, Ore.	2	1	1
Oshkosh Normal School, Oshkosh, Wis.	1	1	1
Pasadena High School, Pasadena, Calif.	1	1	1
Pei-Yang University, Tientsin, China	0	0	1
Pennsylvania College, Gettysburg, Pa.	2	2	2
Pennsylvania Military College, Chester, Pa.	2	2	1
Pennsylvania State College, State College, Pa.	21	23	20
Pennsylvania, University of, Philadelphia, Pa.	28	24	23
Pittsburgh, University of, Pittsburgh, Pa.	23	24	22
Polytechnic School of Engineering, Regents' St., London	1	1	1
Pomona College, Claremont, Calif.	1	1	1
Portland High School, Portland, Me.	0	0	1
Porto Rico, University of, Rio Piedras, P. R.	0	1	1
Pratt Institute, Brooklyn, N. Y.	5	6	5
Princeton University, Princeton, N. J.	7	7	7
Purdue University, LaFayette, Ind.	22	22	21
Queen's University, Kingston, Can.	1	1	1
Queensland, University of, Brisbane, Australia	2	2	2
Reed College, Portland, Ore.	2	1	1
Rensselaer Polytechnic Institute, Troy, N. Y.	5	6	8
Rhode Island State College, Kingston, R. I.	2	2	2
Rice Institute, Houston, Tex.	1	3	3
Riverside Jr. College, Riverside, Calif.	0	0	1
Robert College, Constantinople, Turkey	3	3	2
Rose Polytechnic Institute, Terre Haute, Ind.	4	3	4
Rutgers College, New Brunswick, N. J.	6	7	7
Santa Clara, University of, Santa Clara, Calif.	1	1	1
Saskatchewan, University of, Saskatoon, Canada	1	1	1
Schenley High School, Pittsburgh, Pa.	0	1	1
Sheffield, University of, Sheffield, England	1	1	1
Southern California University, Los Angeles, Calif.	2	2	2
South Dakota State College, Brookings, S. D.	5	5	5
South Dakota, University of, Vermilion, S. D.	3	3	3
Southwestern Presbyterian University, Clarkesville, Tenn.	0	0	1
St. Johns University, Shanghai, China	1	1	1
St. Mary College, Dayton, O.	0	1	1
Stevens Institute of Technology, Hoboken, N. J.	15	15	15
Swarthmore College, Swarthmore, Pa.	2	2	1
Sydney, University of, Sydney, Australia	1	1	1

Syracuse University, Syracuse, N. Y.	9	9	11
Technical High School, Edmonton, Alberta, Canada	1	1	1
Tennessee, University of, Knoxville, Tenn.	4	5	4
Texas A. & M. College, College Station, Tex.	12	12	15
Texas, University of, Austin, Tex.	5	5	5
Texas State School of Mines and Metallurgy, Fort Bliss, Tex.	1	1	1
Throop College of Technology, Pasadena, Calif.	8	8	8
Tokyo Imperial University, Tokyo, Japan	1	1	1
Toledo University, Toledo, O.	1	2	2
Toronto, University of, Toronto, Canada	13	11	9
Trinity College, Hartford, Conn.	1	1	2
Tufts College, Tufts College, Mass.	13	14	11
Tulane University, New Orleans, La.	4	4	4
Union University, Schenectady, N. Y.	9	9	9
United States Naval Academy, Annapolis, Md.	2	2	3
Universidad de Chile, Santiago, Chile	3	3	3
Utah, University of, Salt Lake City, Utah	4	5	4
Valparaiso University, Valparaiso, Ind.	2	2	1
Vanderbilt University, Nashville, Tenn.	1	1	2
Vermont, University of, Burlington, Vt.	8	8	8
Villanova College, Villanova, Pa.	0	1	1
Virginia Episcopal School, Lynchburg, Va.	0	1	1
Virginia Military Institute, Lexington, Va.	2	2	2
Virginia Polytechnic Institute, Blacksburg, Va.	3	4	5
Virginia, University of, University, Va.	15	12	11
Washington & Lee University, Lexington, Va.	1	2	2
Washington State College, Pullman, Wash.	2	3	2
Washington University, St. Louis, Mo.	6	7	6
Washington, University of, Seattle, Wash.	13	11	14
Wentworth Institute, Boston, Mass.	12	13	13
West Philadelphia H. S. for Boys, Philadelphia, Pa.	1	1	1
Western Reserve Univ., Adelbert College, Cleveland, O.	1	1	1
West Virginia University, Morgantown, W. Va.	8	8	9
Whitman College, Walla Walla, Wash.	2	2	2
William and Mary College, Wiliamsburg, Va.	0	1	1
William Hood Dunwoody Inst., Minneapolis, Minn.	0	0	1
Williamson Free School, Williamson School, Pa.	2	2	2
Wisconsin, University of, Madison, Wis.	27	24	23
Wooster, University of, Wooster, O.	1	1	1
Worcester Polytechnic Institute, Worcester, Mass.	16	14	15
Worcester Trade School, Worcester, Mass.	2	1	1
Wyoming, University of, Laramie, Wyo.	4	5	5
Yale University, New Haven, Conn.	22	21	20

GENERAL SUMMARY OF MEMBERSHIP.

March 15, 1918.

Institutions Represented.	
Colleges and Universities Teaching Engineering.	
Domestic	159
Foreign	22
Manual, High, Correspondence and Trade Schools	32
Total Institutions	213
Institutional Members	66
Members	1440
Total Members	1506

GROWTH OF MEMBERSHIP.*

Aug. 20, 1894	**156**	
Sept. 2, 1895	**184**	
Aug. 20, 1896	**200**	**(about)**
Aug. 16, 1897	**203**	
Aug. 18, 1898	**226**	
Aug. 17, 1899	**238**	
July 2, 1900	**249**	
June 29, 1901	**261**	
June 27, 1902	**253**	
July 1, 1903	**271**	
Sept. 1, 1904	**325**	
June 28, 1905	**379**	
July 2, 1906	**400**	
July 1, 1907	**415**	
June 27, 1908	**675**	
June 24, 1909	**759**	
June, 23, 1910	**848**	
June 27, 1911	**1,071**	
June 1912	**1,102**	
June, 1913	**1,158**	
March, 1914	**1,291**	Institutional members.....48
July 1, 1915	**1,403**	Institutional members.....49
March, 1916	**1,447**	Institutional members.....57
March, 1917	**1,447**	Institutional members.....58
March, 1918	**1,440**	Institutional members.....66

*** These figures are taken from the reports of the Secretary, presented at the annual meetings, except the figures for 1914 which were taken from the corresponding year book.**

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS—Membership in the Society shall be of two general classes, Institutional and Individual.

Institutional members shall be educational institutions giving instruction in engineering and scientific subjects.

Individual membership shall be of two classes, Active and Honorary. It shall comprise those persons who occupy or have occupied responsible positions in the work of engineering instruction, together with engineering practitioners and other persons interested in engineering education.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Any individual member not in arrears for dues may become a Life Member by paying Fifty Dollars into the treasury of the Society at one time.

The name of each candidate for individual membership shall be proposed in writing to the Council by two members by whom he is personally known. In the case of a candidate for Institutional membership the name shall be proposed by any member familiar with the work of the institution on receipt of an application signed by a responsible officer thereof. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting, a vote of three-fourths of those present being required to elect; or, during the period between annual meetings, an affirmative letter ballot of three-fourths of those members of the Council whose vote reaches the Secretary within one month from the time of sending out the name of the candidate shall elect. Such letter ballot elections shall be credited to the previous annual meeting and dues shall date from that time, except that elections to membership occurring after

February 1 shall be credited to the next annual meeting and the dues for the remainder of the year shall be one-half the annual dues.

3. OFFICERS—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year, or until their successors have been elected and have qualified. The Officers shall be elected by ballot of the Society at the annual meeting.

4. COUNCIL—The Council of the Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The Officers and the Past Presidents of the Society shall be members of the Council ex-officio.

Any member of the Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates ad interim, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

The President of the Society shall be Chairman of the Council, and the Secretary of the Society shall be Secretary of the Council and shall keep the minutes of its meetings and an accurate record of all its actions.

When votes taken by letter ballot of the Council shall be required, all votes which reach the Secretary within one month from the time of sending out the ballots shall be counted, but votes reaching the Secretary later than the time here specified shall not be counted.

5. NOMINATING COMMITTEE—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES—The admission fee for an individual, active member, which shall also include the first year's dues, shall be Four Dollars ($4.00), and the annual dues, which shall include the subscription price of the BULLETIN, provided for in Art. 8, shall be Four Dollars ($4.00), payable at the time of the annual meeting.

The admission fee for institutional members, which shall also include the first year's dues, shall be Ten Dollars ($10.00), and the annual dues, which shall include the subscription price of three copies of the BULLETIN, and of the PROCEEDINGS, provided for in Art. 8, shall be Ten Dollars ($10.00), payable at the time of the annual meeting.

The fiscal year shall end with the close (or adjournment) of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the PROCEEDINGS, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who has been in arrears more than two years and duly notified by the Secretary, shall be dropped from the roll, until such arrearages are paid.

7. MEETINGS—There shall be an annual meeting at such time and place as the Society at the preceding annual meeting, or the Council may determine.

8. PUBLICATIONS—The publications of the Society shall include an annual volume of PROCEEDINGS, to be published and distributed to the membership as soon as possible after the annual meeting; and a monthly BULLETIN, to be published from September to June, inclusive.

9. AMENDMENTS—This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the Society provided the amendment shall have been approved by the Council by letter ballot by a two-thirds vote of the members voting.

BY-LAWS OF THE SOCIETY AND RULES GOVERNING THE COUNCIL.

First. The Officers of the Society shall constitute a Committee to arrange for the annual meeting and to prepare a program for the same.

Second. The President, the Secretary and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of appropriations to Committees and for other purposes, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

Third. Expenditures of money may be made only in accordance with a definite appropriation or by direct vote of the Executive Committee.

Fourth. Reading of papers shall be limited to fifteen minutes each or to such other time as may be designated by the Program Committee, and abstracts of papers of about three hundred words shall be printed when practicable, and distributed in advance to the members.

Fifth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

Sixth. The President, the Secretary and the retiring Secretary shall constitute a Publication Committee, of which the Secretary shall be Chairman, to edit and have charge of the publication of the monthly BULLETIN and the PROCEEDINGS of the Society, except the volume of Proceedings of the last convention, which shall be edited by the retiring

Secretary. If at any time there be no retiring Secretary the retiring President shall be a member of this Committee.

Seventh. The Officers, members of the Council and members of the local Convention Committee shall constitute a Committee on Sociability to introduce members and guests to each other at the annual meetings and in general to promote a spirit of good fellowship.

Eighth. The subscription price of the BULLETIN shall be One Dollar per year, payable in advance.

Ninth. Additions or amendments may be made to these By-Laws at any regular meeting of the Society, on the recommendation of the Council by a two-thirds affirmative vote of the Council and of the Society.

PUBLICATIONS.

The publications of the Society can be obtained from the Secretary. The current issues are distributed gratuitously to members in good standing, one copy of each to each individual member and three to each institutional member. The price of the bound volumes of the PROCEEDINGS of former years is $2.50 to non-members, $2.00 to public libraries, and $1.50 to members for their own libraries.

The BULLETIN is issued monthly from September to June. The price to non-members is $2.00 per year. Libraries may order the BULLETIN and the PROCEEDINGS at $4.00 per year.

Reprints of papers may be ordered when the papers are in type form, and either with or without covers, at a price depending upon the number of pages and copies desired.

PAST OFFICERS

Special Committee for Division E, Engineering Education, World's Engineering Congress, 1893.

IRA O. BAKER, Chairman,
HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary,
C. FRANK ALLEN, Sec'y, *pro tem.*,
MORTIMER E. COOLEY,
SAMUEL W. STRATTON,
STORM BULL.*

PRESIDENTS

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON,* 1897–8,
THOS. C. MENDENHALL, 1898–9.
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN,* 1900–1,
ROBERT FLETCHER, 1901–2,
CALVIN M. WOODWARD,* 1902–3,
C. FRANK ALLEN, 1903–4,
FRED W. McNAIR, 1904–5,
CHARLES L. CRANDALL,* 1905–6,
DUGALD C. JACKSON, 1906–7,
CHARLES S. HOWE, 1907–8,
FRED. E. TURNEAURE, 1908–9,
HENRY S. MUNROE, 1909–10,
ARTHUR N. TALBOT, 1910–11,
WM. G. RAYMOND, 1911–12,
WM. T. MAGRUDER, 1912–13,
G. C. ANTHONY, 1913–14,
ANSON MARSTON, 1914–15,
HENRY S. JACOBY, 1915–16,
GEORGE R. CHATBURN, 1916–17.

VICE-PRESIDENTS

SAMUEL B. CHRISTY,* GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON,* FRANK O. MARVIN,* 1894–5,
FRANK O. MARVIN,* CADY STALEY, 1895–6,
JOHN GALBRAITH,* JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER,* 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY,* ALBERT KINGSBURY, 1900–1,
STORM BULL,* CALVIN M. WOODWARD,* 1901–2,
JOHN J. FLATHER, FRED W. McNAIR, 1902–3,
CHARLES L. CRANDALL,* JAMES C. NAGLE, 1903–4,
CLEMENT R. JONES, ELWOOD MEAD, 1904–5,
WILLIAM T. MAGRUDER, JOHN P. JACKSON, 1905–6,
R. C. CARPENTER, CHARLES S. HOWE, 1906–7,
CLARENCE A. WALDO, WILLIAM G. RAYMOND, 1907–8,
MORTIMER E. COOLEY, OLIN H. LANDRETH, 1908–9,

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* Deceased.

ARTHUR N. TALBOT, ARTHUR L. WILLISTON, 1909–10,
MILO S. KETCHUM, WILLIAM KENT, 1910–11,
G. C. ANTHONY, F. B. GILBRETH, 1911–12,
L. S. MARKS, F. W. SPERR, 1912–13,
H. S. JACOBY, D. C. HUMPHREYS, 1913–14,
H. H. NORRIS, C. RUSS RICHARDS, 1914–15,
G. R. CHATBURN, F. H. CONSTANT, 1915–16.
HOLLIS GODFREY, WM. M. THORNTON, 1916–17.

TREASURERS

STORM BULL,* 1893–5,
JOHN J. FLATHER, 1895–9,
CLARENCE A. WALDO, 1899–1902,
ARTHUR N. TALBOT, 1902–4,
FRED. P. SPALDING, 1904–6,
ANSON MARSTON, 1906–7.

SECRETARIES

JOHN B. JOHNSON,* 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900,
HENRY S. JACOBY, 1900–2,
CLARENCE A. WALDO, 1902–4,
MILO S. KETCHUM, 1904–6,
WILLIAM T. MAGRUDER, 1906–7,
ARTHUR L. WILLISTON, 1907–9,
HENRY H. NORRIS, 1909–14.

MEMBERS OF PREVIOUS COUNCILS

Terms of Office Expired in 1894.

M. E. COOLEY, H. T. EDDY, W. F. M. GOSS,
W. R. HOAG, S. W. ROBINSON,* H. W. SPANGLER,
R. H. THURSTON.*

Terms of Office Expired in 1895.

H. T. BOVEY,* W. H. BURR, O. H. LANDRETH,
MANSFIELD MERRIMAN, W. G. RAYMOND, G. F. SWAIN,
DE VOLSON WOOD.*

Terms of Office Expired in 1896.

I. O. BAKER, STORM BULL,* S. B. CHRISTY,*
JOHN GALBRAITH,* J. B. JOHNSON,* F. O. MARVIN,*
C. D. MARX.

Terms of Office Expired in 1897.

H. T. EDDY, J. J. FLATHER, J. P. JACKSON,
ALBERT KINGSBURY, L. S. RANDOLPH, S. W. ROBINSON,*
R. H. THURSTON.*

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* Deceased.

MEMBERS OF PREVIOUS COUNCILS.

Terms of Office Expired in 1898.

C. F. Allen, C. L. Mees, Mansfield Merriman,
J. M. Ordway, W. G. Raymond, Cady Staley,
R. S. Woodward.

Terms of Office Expired in 1899.

Arthur Beardsley, Robert Fletcher, John Galbraith,*
William Kent, T. C. Mendenhall, W. H. Schuerman,
M. E. Wadsworth.

Terms of Office Expired in 1900.

Storm Bull,* L. G. Carpenter, Albert Kingsbury,
F. O. Marvin, R. B. Owens, R. L. Sackett,
R. H. Thurston.*

Terms of Office Expired in 1901.

T. N. Drown,* M. A. Howe, I. N. Hollis,
Gaetano Lanza, P. C. Ricketts, R. G. Thomas,
C. M. Woodward.*

Terms of Office Expired in 1902.

Brown Ayres, G. W. Bissell, J. J. Flather,
W. T. Magruder, F. W. McNair, J. M. Porter,
A. J. Wood.

Terms of Office Expired in 1903.

C. F. Allen, D. C. Jackson, N. C. Ricker,
J. P. Brooks, Edgar Marburg, A. L. Williston,
J. C. Nagle.

Terms of Office Expired in 1904.

W. F. M. Goss, Thomas Gray,* D. C. Humphreys,
O. H. Landreth, W. G. Raymond, L. E. Reber,
L. S. Randolph.

Terms of Office Expired in 1905.

Wm. Esty, L. J. Johnson, W. M. Towle,
H. S. Jacoby, Elwood Mead, J. L. Van Ornum,
Edward Orton, Jr.

Terms of Office Expired in 1906.

John Galbraith,* Charles S. Howe, Walter M. Riggs,
Frederick P. Spalding, Henry W. Spangler,* Fred. E. Turneaure,
Herman K. Vedder.

Terms of Office Expired in 1907.

Thomas Gray,* James C. Nagle, William G. Raymond,
Louis E. Reber, Arthur N. Talbot, Clarence A. Waldo,
Robert S. Woodward.

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* Deceased.

Terms of Office Expired in 1908.

VICTOR C. ALDERSON,
FRANCIS C. CALDWELL,
ARTHUR H. FORD,
HENRY S. MUNROE,
FREDERICK W. SPERR.
H. P. TALBOT,
A. L. WILLISTON,

Terms of Office Expired in 1909.

CHARLES F. BURGESS,
ARTHUR M. GREENE, JR.,
JOHN F. HAYFORD,
MILO S. KETCHUM,
HENRY H. NORRIS.
THOMAS W. PALMER,
JOSEPH A. THALER,

Terms of Office Expired in 1910.

FRED W. ATKINSON,
MORTIMER E. COOLEY,
WALTER B. RUSSELL,
WILLIAM KENT,
HAROLD B. SMITH.
WILLIAM S. FRANKLIN,
CHARLES F. SCOTT,

Terms of Office Expired in 1911.

LESTER P. BRECKENRIDGE,
THOMAS GRAY,*
LEWIS J. JOHNSON,
WILLIAM T. MAGRUDER,
CLARENCE A. WALDO.
WILLIAM G. RAYMOND,
HERMAN SCHNEIDER,

Terms of Office Expired in 1912.

FRANK H. CONSTANT,
FREDERICK A. GOETZE,
H. WADE HIBBARD,
JOHN H. LEETE,
CHAS. RUSS RICHARDS.
EDW. R. MAURER,
JOHN C. OSTRUP,

Terms of Office Expired in 1913.

C. H. BENJAMIN,
G. W. BISSELL,
E. E. BRYDONE-JACK,
W. H. P. CREIGHTON,
H. W. TYLER.
J. F. HAYFORD,
C. RUSS RICHARDS,

Terms of Office Expired in 1914.

J. E. BOYD,
C. H. CROUCH,
F. L. EMORY,
C. E. MAGNUSSON,
H. H. STOEK.
J. A. L. WADDELL,
A. J. WOOD,

Terms of Office Expired in 1915.

F. L. BISHOP,
G. R. CHATBURN,
O. P. HOOD,
G. D. SHEPARDSON,
F. P. MCKIBBEN.
W. B. SNOW,
J. C. TRACY,

Terms of Office Expired in 1916.

J. F. HAYFORD,
M. S. KETCHUM,
A. S. LANGSDORF,
F. P. SPALDING,
H. W. TYLER.
P. F. WALKER,
S. M. WOODWARD,

Terms of Office Expired in 1917.

R. H. FERNALD,
A. H. FULLER,
A. M. GREENE, JR.,
E. V. HUNTINGTON,
V. KARAPETOFF,
D. C. MILLER,
W. M. RIGGS.

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* Deceased.

DECEASED MEMBERS.

NAME.	YEAR OF ELECTION.	DATE OF DEATH.	MEMOIR. Vol. Page.
C. L. ADAMS	1904	Sept. 16, 1914.	XXII, 414
PHILIP R. ALGER	1909	February 23, 1912.	XX, Part II, 491
WILLIAM A. ANTHONY	1907	May 29, 1908.	XVI, 409
GEORGE W. ATHERTON	1904	July 24, 1906.	XIV, 292
WARREN BABCOCK	1908	May, 1913.	XXI, 434
VOLNEY C. BARBOUR	1894	June 4, 1901.	IX, 340
G. E. BRAY	1915	September 1, 1917.	
CHARLES B. BRUSH	1893	June 3, 1897.	VII, 181
STORM BULL	1893	November 18, 1907.	XVI, 407
OCTAVE CHANUTE	1907	November 23, 1910.	XIX, 501
S. B. CHARTERS, JR.	1911	December 29, 1912.	XX, Part II, 493
S. B. CHRISTY	1893	November 30, 1914.	XXII, 415
ELMER CORTHELL	1895		
ECKLEY B. COXE	1894	May 13, 1895.	VII, 182
CHAS. L. CRANDALL	1893	August 25, 1917.	
E. W. DAVIS	1902	February 3, 1918.	
CHAS. S. DENISON	1893	July 31, 1913.	XXII, 411
W. P. DICKINSON	1909	November 4, 1915.	
A. J. DUBOIS	1894	October 19, 1915.	XXV,
LOUIS DUNCAN	1904	March 12, 1915.	XXIV, 337
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BULLETIN

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SOME EFFECTS OF THE WAR ON ENGINEERING EDUCATION IN THE PACIFIC NORTHWEST.*

BY C. E. MAGNUSSON,

Acting Dean, University of Washington.

Only a very limited discussion of the effects of the War on engineering education can be attempted at this time, as the action is still in progress, with tendencies so uncertain as to make predictions useless even for the immediate future. For a comparative study of the tendencies in the several sections of the country, the following data from the University of Washington as a representative of the Pacific Northwest may be of interest.

(*a*) *Four-Quarter System.*—Shortly after the declaration of war, the University of Washington changed from the two-semester to the four-quarter system in order to speed up the training of students, especially in engineering and medicine.

This summer a full quarter's work will be offered in civil, electrical, mechanical and chemical engineering.

(*b*) *New Courses.*—To meet the demand for technical training required in war service, new courses are given this year in shipdrawing, ship design, theory of aviation, airplane design, marine engineering, navigation, radio engineering, military French, sanitation, bacteriology, pharmacy and military science. A large number of lectures have been given by faculty members to the soldiers at Camp Lewis, American Lake Cantonment.

(*c*) *New Curricula.*—At the opening of the third quarter this year, regular four year curricula will be offered in military training, naval training and aviation, leading to commissions in the Army and Navy.

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* This is the third of a series of articles on the effects of the war on engineering education being published in this magazine.

(*d*) *War Service.*—The preliminary *honor roll* of students and alumni in the Army and Navy contains fifteen hundred and eighty-four (1584) names. For lack of definite information, the *roll* has many omissions and the corrected figures will probably exceed two thousand (2,000). Most of the students who did not return to the university last fall are now in active military service.

As an example, may be mentioned that out of thirty-seven (37) men in last year's junior class in electrical engineering, twenty-two (22) are now serving either in the Army or the Navy.

Of the members of the engineering faculty, Major W. F. Allison is now ''somewhere in France''; Captain C. C. More in the Ordnance Department in Washington; Captain H. G. Byers is with the 30th Engineers; Lieutenant H. L. Trumbull is in Washington; and Professors E. A. Loew and J. W. Miller are giving expert service in the nitrate industry and airplane manufacture respectively.

Military training has been increased to eight hours per week. Nineteen faculty members took special training in military science last spring and summer, and are now serving as captain-instructors in the Reserve Officers Training Corps, in which most of the students in engineering are enrolled.

(*e*) *Enrollment.*—Probably enrollment data are the most commonly used basis in making comparisons between educational institutions; and the following figures for the College of Engineering may be of interest:

Total enrollment, the year 1916–17	536
Total enrollment, first two quarters, 1917–18	363

Percentage of students in 1917–18, compared to the enrollment of 1916–17:

Seniors	Juniors	Sophomores	Freshmen	Total
70%	48%	45%	94%	68%

The enrollment for 1916–17 was slightly below normal.

REINFORCED CONCRETE THEORY WITHOUT THE AID OF FORMULAS.

BY CHARLES A. ELLIS,

Professor of Structural Engineering, University of Illinois.

Willie had an awful thirst,
But Willie is no more;
For what he thought was H_2O
Was H_2SO_4.

Whether the formula be rational or empirical, engineering or medical, it is a dangerous instrument except in the hands of experts. A formula frequently plays havoc with an engineering structure when used by a designer who knows not its history, meaning or limitations. But this is by no means the only instance when its use is hazardous. In the class-room, formulas should be given whatever prominence they deserve at the *end* of the course and not at the beginning, for the simple reason that they do more harm than good, when introduced earlier, by obscuring physical relations which should be visualized to the highest degree.

Gauss, one of the greatest physical mathematicians of the nineteenth century, remarked that many of the most celebrated mathematicians, Euler very often, Lagrange sometimes, had trusted too much to the symbolic calculation of their problems, and would not have been able to give an account of the meaning of each successive step in their investigations. Gauss said that he himself, on the other hand, could assert that at every step which he took he always had the aim and purpose of his operations before his eyes without ever turning aside from the way. ''The same,'' he remarks, ''might be said of Newton.''

The standard text-books on the theory of reinforced concrete are probably the best examples of formulas running riot. The procedure for the investigation or design of a beam usually follows this order: Algebraic symbols are given to the various data; the solution appears in the disguise of a group of a half dozen or more formulas; ever thereafter the numerical values are assigned to the algebraic symbols, the crank is turned and out pops the answer. The whole essence of the ultimate good resulting from mental discipline is lost; the fundamentals are obscured by the algebraic "substitution in the formula"; and what might have been an interesting and instructive problem falls to the level of a high-school exercise in algebra.

The formula method necessarily presents mathematical principles in generalities first, and particulars last. A history of any science will show that its development has been induced in the reverse order. A science should be presented to the student in the order of sequence most natural for the grasp of the human intellect, which can be no other than that by which all science is developed, namely, by progress from the particular to the general. Any other order is as confusing to the mind of the student as would be an attempt to interpret the plot of a movie drama, when the film is made to run backward.

The foregoing statements have been expressed by the present writer in a previous article;* and he has received several letters asking how a course in the theory of reinforced concrete might be conducted without the use of formulas, when using a text-book which adopted the formula method. An attempt to answer this question is the purpose of this paper.

Hool's *Reinforced Concrete Construction*,* Vol. I, is used as a text. Several recitations are given to the discussion of properties of materials, as set forth in Part I; after which the following problem is assigned.

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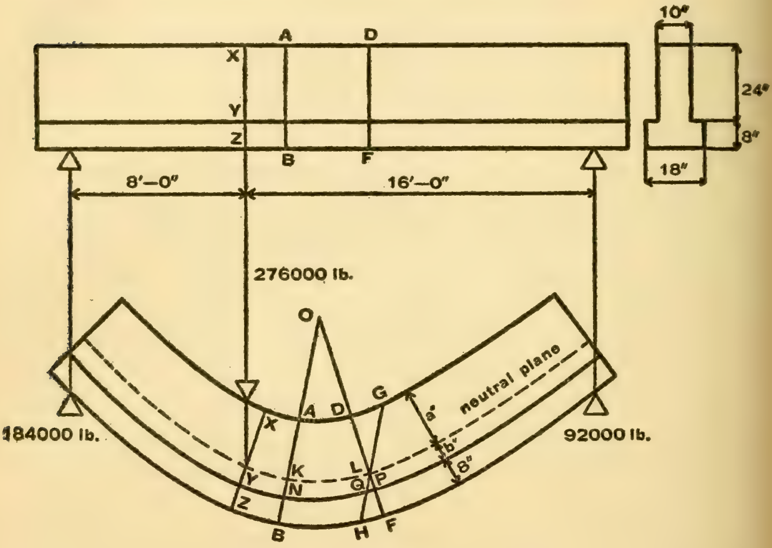
* "Graphical Calculus with Special Reference to Shear, Moment and Deflection Diagrams," *Journal of Western Society of Engineers*, April, 1917.

* The writer wishes it to be understood that this paper is in no sense to be construed as a criticism of this particular text-book. The fact that it is used in more than 80 institutions would discount 100 per cent. any criticism which he might offer.

Fig. 1 represents a *homogeneous* beam supporting one concentrated load. What is the tensile or compressive unit-stress at X? At Y? At Z? Neglect weight of beam.



This course, given in the first semester of the senior year, is required of civil engineering students who completed their course in Mechanics of Materials in the first semester of their junior year. Consequently it is unnecessary to comment upon the solutions submitted at the following recitation. No doubt the situation recalls to the reader many similar harrowing experiences.

The members of the class are given an oral quiz upon the formula which all have attempted to apply. An elevation of the beam is sketched upon the blackboard; a horizontal line is drawn through the elevation and several points on the line are designated. As the crayon moves from one point to another, a student is asked to name the symbols in his formula which represent variables. The exercise is repeated with a vertical line and perhaps with a diagonal line. Attention is also directed to the meaning of each symbol and the unit of measure. At the end of a rigorous quiz of thirty minutes the class is usually in a receptive mood and the following dictation is given.

The Bernoulli-Eulerian hypothesis or common theory of beams rests upon three principles which, when applied to a horizontal beam resisting vertical forces, not eccentric, may be stated as follows:

1. At any cross-section the sum of the horizontal tensile stresses equals the sum of the horizontal compressive stresses.

2. If two parallel lines are drawn close together on the side of the beam, perpendicularly to its length, before it is loaded; these lines, when the beam is loaded by any reasonable amount and bent by that loading, will still be straight as far as can be observed from careful examination; but they will converge to a point known as the center of curvature for that part of the beam.

3. The unit-stress is proportional to the unit-strain (unit shortening or lengthening) or $\frac{\textit{unit-stress}}{\textit{unit-strain}} =$ *modulus (measure) of elasticity (E), a ratio which varies for different materials.*

The first principle is a rational fact. The second and third principles are empirical assumptions which, although not strictly true, are sufficiently applicable in a reasonable design where the unit-stresses do not exceed the elastic limit of the material.

The same problem is assigned for the next lesson with the added instruction *that no formula is to be used;* but that the solution is to be based directly upon the three principles. The students are very much at sea. They attack the problem with about the same measure of success as attends an attempt to grasp a twenty four-inch sphere with one hand. Finally, however, after *much* discussion and *little* guidance the following solution appears.

If parallel lines *AB* and *DF* (Fig. 1) are drawn upon the side of the beam before it is loaded, they will remain straight lines after it bends (second principle), but will converge and meet in some point *O,* if produced. The upper layers of the beam have been shortened; the lower layers have been lengthened; and a layer *KL,* situated somewhere between the top and bottom, remains unchanged in length. This layer separates the compressed and stretched portions and, being "strictly neutral," is called the neutral layer or neutral plane, the location of which is the first objective.

Draw *GLH* parallel to *AB.* Since in a practical beam the radii of the curved layers *AG, KL* and *BH* are very great when compared with the depth of the beam,* the lengths of the several layers between *AB* and *GH* may (without appreciable error) be considered equal. *DG* will represent the shortening which *AG* has undergone in its reduction to *AD; QP* will represent the stretch which *NQ* has endured in its elongating to *NP;* likewise *HF* will represent the stretch which *BH* has experienced in its lengthening to *BF.* If the several layers between *AB* and *GH* are taken as a unit of length, the corresponding length of that part of any layer between the line *DF* and *GH* will represent the shortening or lengthening of that layer in a unit of length. In other words, *DG* will represent the unit-strain for the top layer and *HF* that for the bottom layer, etc.

Since *DF* and *GH* are straight lines (second principle) intersecting at *L* on the neutral plane, it follows that the *unit-strain of any layer is proportional to the distance of that layer from the neutral plane,* or

$$\frac{a}{DG}=\frac{b}{QP}=\frac{b+8}{HF}.$$

---

* The representation of the deflection is grossly exaggerated in the figure. If the two lines *AB* and *DF* were drawn one inch apart and near the load where the curvature is the greatest, their intersection point *O* for a steel beam would be nearly one mile above the beam.

Since this beam is composed of a homogeneous material throughout, the modulus of elasticity is the same for all ratios of unit-stress to unit-strain (third principle).

Let f_c represent the unit-stress corresponding to the unit-strain DG,
f_x represent the unit-stress corresponding to the unit-strain QP,
and f_t represent the unit-stress corresponding to the unit-strain HF.

Then

$$\frac{f_c}{DG} = \frac{f_x}{QP} = \frac{f_t}{HF}.$$

But

$$\frac{a}{DG} = \frac{b}{QP} = \frac{b+8}{HF};$$

hence

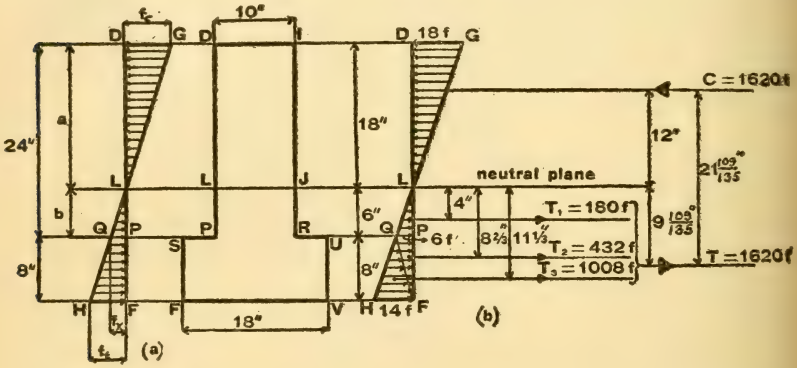
$$\frac{f_c}{a} = \frac{f_x}{b} = \frac{f_t}{b+8}$$

or

$$f_c : f_x : f_t :: a : b : b + 8.$$

Therefore at any cross-section of a *homogeneous* beam the unit-stress (intensity of the stress) caused by bending is uniformly varying, with a maximum tensile unit-stress on the convex side and a maximum compressive unit-stress on the concave side; provided, of course, that the beam is so loaded that the unit-stresses in no case exceed the elastic limit of the material. Or in other words: Since the unit-strain varies as its distance from the neutral plane (second principle) and since the unit-stress varies as the unit-strain (third principle), it follows that for *homogeneous beams, the tensile or compressive unit-stresses vary as their distances from the neutral plane.*

The neutral plane may now be located by equating the sum of the tensile stresses to the sum of the compressive stresses (first principle). For convenience the conventional diagram is redrawn in Fig. 2a where GD, QP and HF may represent the unit-stresses f_c, f_x and f_t respectively. The neutral plane is assumed to lie in the stem of the beam rather than in the flange, that is, the distance $DL = a$ is assumed to be less than 24 inches.



The cross-sectional area $DIJL$, which is 10 inches wide and a inches deep $= 10a$ square inches, is subjected to compressive stresses. The intensity of stress is f_c pounds per square inch at DI and uniformly decreases to zero at LJ; hence the *average* intensity or the *average* unit-stress is $\frac{1}{2}f_c$ pounds per square inch. The sum of the compressive stresses therefore is

$$C = \tfrac{1}{2}f_c\ 10a = 5af_c \text{ lb.}$$

The tensile stress below the neutral plane on the area $LJRP$ is $\frac{1}{2}f_x$ $10b$ lb.; on the area $SUVF$ the tensile stress is $\dfrac{f_x + f_t}{2}$ 144 lb.

The sum of the tensile stresses therefore is

$$T = 5b\,f_x \text{ lb.} + 72(f_x + f_t) \text{ lb.}$$

From the first principle

$$C = T$$

or

$$5af_c = 5bf_x + 72f_x + 72f_t.$$

From the second and third principles

$$f_x : f_t :: b : b + 8 \text{ or } f_x = \frac{bf_t}{b+8}$$

and

$$f_c : f_t :: a : b + 8 \text{ or } f_c = \frac{af_t}{b+8}.$$

Therefore

$$5a\frac{af_t}{b+8} = 5b\frac{bf_t}{b+8} + 72\frac{bf_t}{b+8} + 72f_t$$

or

$$5a^2 = 5b^2 + 144b + 576,$$

but

$$a + b = 24.$$

Hence $a = 18$ inches and $b = 6$ inches.

If the neutral plane had been assumed to be below the top of the flange *SU* instead of above it, the solution would have given for b the value -6.

The neutral plane is now definitely located 18 inches below the top of the beam. Let f represent the unit-stress (tensile or compressive) for either layer *one inch* above or below the neutral plane (Fig. 2*b*). Then $18f$ is the compressive unit-stress on the top of the stem; $6f$ is the tensile unit-stress along the top of the flange; and $14f$ is the tensile unit-stress on the bottom of the flange.

The total compression on the area *DIJL* is

$$C = \frac{18f}{2} \times 18 \times 10 = 1{,}620f \text{ lb.}$$

The tension on the area *LJRP* is

$$T_1 = \frac{6f}{2} \times 6 \times 10 = 180f \text{ lb.}$$

The tension on the area *SUVF* will be considered in two portions. Let T_2 equal the sum of the unit-stresses represented by the triangle *QPF*, and T_3 equal the sum represented by the triangle *QHF*. Then

$$T_2 = \frac{6f}{2} \times 8 \times 18 = 432f \text{ lb.}$$

and

$$T_3 = \frac{14f}{2} \times 8 \times 18 = 1{,}008f \text{ lb.}$$

The total tension is $T = T_1 + T_2 + T_3$.

$$\begin{array}{l}
T_1 = \phantom{1{,}}180f \text{ lb.} \\
T_2 = \phantom{1{,}}432f \text{ lb.} \\
\underline{T_3 = 1{,}008f \text{ lb.}} \\
T \ = 1{,}620f \text{ lb.} = C
\end{array}$$

The line of action of the sum (C) of the compressive stresses is through the centroid of the triangle *DLG*, 12 inches above the neutral plane. Similarly, T_1 acts 4 inches below the neutral plane; T_2, $8\frac{2}{3}$ inches, and T_3, $11\frac{1}{3}$ inches below the neutral plane.

The location of T is found as follows:

$$\begin{array}{rlrl}
180f \text{ lb.} & \times\ 4 \text{ in.} = & 720f & \text{in.-lb.} \\
432f\text{ ''} & \times\ 8\frac{2}{3}\text{ ''} = & 3{,}744f & \text{'' ''} \\
\underline{1{,}008f\text{ ''}} & \times\ 11\frac{1}{3}\text{ ''} = & \underline{11{,}424f} & \underline{\text{'' ''}} \\
1{,}620f \text{ lb.} & & \underline{)15{,}888f} & \underline{\text{in.-lb.}} \\
& & 9^{109}/_{135} & \text{in.}
\end{array}$$

The line of action of T is $9^{109}/_{135}$ inches below the neutral plane.

The two resultant stresses C and T form the resisting couple. The lever arm is $12 + 9^{109}/_{135} = 21^{109}/_{135}$ inches. The moment of this stress couple which resists the bending moment of the external forces is

$$M = 1{,}620f \text{ lb.} \times 21^{109}/_{135} \text{ in.} = 35{,}328f \text{ in.-lb.}$$

The magnitude of f, which is the unit-stress at any cross-section on either side of the neutral plane and one inch from it, is found by equating the internal resisting stress couple to the moment of the external forces about the given cross-section and solving for f.

The moment of the external forces about the section XYZ (Fig. 1) is

$M = 184{,}000 \text{ lb.} \times 8 \text{ ft.} = 1{,}472{,}000 \text{ ft.-lb.} = 17{,}664{,}000 \text{ in.-lb.}$

Hence

$$35{,}328f = 17{,}664{,}000,$$

$$f = \frac{17{,}664{,}000 \text{ in.-lb.}}{35{,}328 \text{ in.}^3} = 500 \frac{\text{lb.}}{\text{in.}^2} \text{ or } 500 \text{ lb. per sq. in.*}$$

The unit-stress varies uniformly as the distance from the neutral plane. Hence, if at section XYZ the unit-stress one inch from the neutral plane is 500 lb. per sq. in.; at X, or 18 inches above the neutral plane, the unit-stress is $18 \times 500 = 9{,}000$ lb. per sq. in. compressive. Similarly at Y the unit-stress is 3,000 lb. per sq. in. tensile; and at Z, 7,000 lb. per sq. in. tensile.

---

* Much emphasis is given to the units of measure. For example, in the expression $C = \frac{18f}{2} \times 18 \times 10 = 1{,}620f$ lb., it should be noted that $\frac{18}{2}$ is a ratio; f represents lb. per sq. in. or $\frac{\text{lb.}}{\text{in.}^2}$; 18 and 10 express inches, hence the coefficient 1,620 represents in.^{2}. The term $1{,}620f$ represents in.^{2} $\times \frac{\text{lb.}}{\text{in.}^2} = $ lb. Frequently, the units of measure are written directly below the equation thus.

$$M = 1{,}620f \times 21\frac{109}{135} = 35{,}328f$$

$$\text{in. lb.} = \text{in.}^2 \times \frac{\text{lb.}}{\text{in.}^2} \times \text{in.} \;\; = \text{in.}^3 \frac{\text{lb.}}{\text{in.}^2}$$

Students who previously found, by using the formula method, that the moment of inertia of the cross-section about the horizontal centroidal axis was 35,328 inches^4 will usually ask why the quantity 35,328 as here used expresses inches^3. This question gives an opportunity for some other student to make the reconciliation.

The method here given lays no claim to brevity. It is believed, however, that if the student is required to solve several problems by this method he will more quickly and thoroughly understand the "insides" of a beam than will be the case if he devotes his time to algebraic substitutions in a formula.* Little or no reference is made to the horizontal centroidal axis, moment of inertia or section modulus in this solution when used as an introduction to reinforced concrete theory.

It usually requires two class periods in which to develop the solution given above. The solution is never given in the form of a lecture; such procedure too frequently defeats its own purpose. Consistent, constant oral quizzing with an occasional suggestion is far more efficient in developing mental ability in the student.

At the close of the period in which the solution is completed, a second problem similar to the first, but with a different form of cross-section, is assigned. The solutions are submitted at the beginning of the next recitation, and the following problem is discussed in class.

A tension member consists of 3 steel eye-bars, each 10 in. wide and 1 in. thick. The center-to-center distance of pins is 50 feet. The diameter of the holes in the two outside bars is 7.1 inches; the diameter of the holes in the middle bar is 7 inches. The pins are a driving fit in the holes of the middle bar. What stress will each bar take if the member is pulling 130 tons, and what will be the center-to-center distance of the pins?

Call the modulus of elasticity of steel 30,000,000 lb. per sq. in. The middle bar must stretch 1/10 of an inch in 600 inches (50 feet) before the other bars begin to act. In each inch of the middle bar, the stretch or unit-strain is

---

* But if we must use a formula let us choose symbols which will not suggest a wrong interpretation. In a text which is open before me I find the formula $M = SI/c$, where c is explained as representing the distance from the neutral axis to the side of the beam furthest from that axis. The very fact that the symbol c is used suggests that it represents a constant for a beam of uniform cross-section. This is a very narrow and frequently misleading interpretation.

$$\frac{1 \text{ in.}}{6{,}000 \text{ in.}} = \frac{1}{6{,}000}.$$

From the third principle

$$\frac{\text{unit-stress}}{\frac{1}{6{,}000}} = 30{,}000{,}000 \text{ lb. per sq. in.},$$

or the unit-stress is 5,000 lb. per sq. in.; and the total stress in the middle bar at the time when the outside bars begin to act is 5,000 lb. per sq. in. times 10 sq. in. = 50,000 lb.

At this point the three bars divide the remaining load of 210,000 lb., causing a unit-stress of 7,000 lb. per sq. in. in each outside bar and adding 7,000 lb. per sq. in. to the initial stress of the middle bar, making in all 12,000 lb. per sq. in. for that bar.

For the outside bars,

$$\frac{7{,}000 \text{ lb. per sq. in.}}{\frac{\text{total stretch}}{600 \text{ in.}}} = 30{,}000{,}000 \text{ lb. per sq. in.},$$

hence, their total stretch $= \dfrac{7{,}000 \times 600}{30{,}000{,}000} = 0.14$ in.

For the middle bar,

$$\text{the total stretch} = \frac{12{,}000 \times 600}{30{,}000{,}000} = 0.24 \text{ in.}$$

Hence 600.24 in. = center-to-center distance of pins.

The eye-bar problem solved during the recitation period paves the way for the following problem to be solved by the class and submitted at the following period.

A 12 in. × 12 in. timber is reinforced on two opposite sides with a 12 in. × ¼ in. steel plate for its full length of 30 ft., in such a manner that the wood and steel act together when under a tension of 158,400 lb.

How is the stress divided between the wood and steel?

The solutions usually appear as follows:

Let

$$f_s = \text{unit-stress in steel}$$

and

$$f_w = \text{unit-stress in wood.}$$

Assume modulus of elasticity = 30,000,000 lb. per sq. in. for steel and 1,500,000 lb. per sq. in. for wood. If the two materials act together the unit-stretch must be the same for each, therefore

$$\frac{f_s}{\text{unit-stretch}} = 30{,}000{,}000; \quad \frac{f_w}{\text{unit-stretch}} = 1{,}500{,}000$$

or

$$\text{unit-stretch} = \frac{f_s}{30{,}000{,}000} = \frac{f_w}{1{,}500{,}000},$$

hence

$$f_s = 20f_w.$$

The timber has 144 sq. in. of cross-section and the steel 6 sq. in.

$$144f_w + 6f_s = 158{,}400,$$

$$144f_w + 120f_w = 158{,}400,$$

$$f_w = 600 \text{ lb. per sq. in.},$$

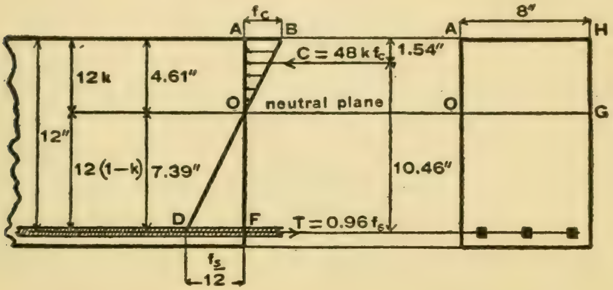
$$f_s = 20f_w = 12{,}000 \text{ lb. per sq. in.},$$

$$\begin{aligned} 144 \times 600 &= 86{,}400 \text{ lb.} = \text{stress in timber}, \\ 6 \times 12{,}000 &= \underline{72{,}000 \text{ lb.}} = \text{`` `` steel}, \\ & 158{,}400 \text{ lb.} = \text{total stress.} \end{aligned}$$

This problem brings out the important fact that if two materials *act together their unit-strains must be equal, consequently their unit-stresses are proportional to their moduli of elasticity.*

Paragraph 26 of the text, dealing with the behavior of reinforced concrete under tension, is reviewed; the reasons for neglecting the tensile stresses in the concrete below the neutral plane are brought out by discussion; and the class is ready to proceed with the illustrative problem, foot of page 56.

Illustrative Problem. What will be the resisting moment (M) for a beam whose breadth (b) is 8 in. with a distance from the center of the reinforcement to the compression surface (d) of 12 in., the area of steel section being 0.96 sq. in.?



$E_s = 30{,}000{,}000$ lb. per sq. in. $E_c = 2{,}500{,}000$ lb. per sq. in.
$f_c = 500$ lb. per sq. in. $f_s = 16{,}000$ lb. per sq. in.

As in the homogeneous beam, the first task is to locate the neutral plane OG (Fig. 3). Let BA represent the shortening in a unit-length of concrete, or the unit-strain on the top surface; and DF the stretch in a unit-length of steel, or unit-strain. The *unit-strains* are proportional to their distances from the neutral plane (as in first problem), hence

$$12k : 12(1-k) :: BA : DF$$

or

$$k : 1-k :: BA : DF.$$

Let f_c represent the unit-stress in the concrete corresponding to the unit-strain BA; and f_s represent the unit-stress in the steel corresponding to the unit-strain DF.

The moduli of elasticity of concrete and steel are assumed to be 2,500,000 and 30,000,000 lb. per sq. in. respectively; hence from the third principle,

$$\frac{f_c}{BA} = 2{,}500{,}000 \quad \text{and} \quad \frac{f_s}{DF} = 30{,}000{,}000$$

or

$$BA = \frac{f_c}{2{,}500{,}000} \quad \text{and} \quad DF = \frac{f_s}{30{,}000{,}000},$$

therefore

$$BA : DF :: f_c : f_s/12$$

or, if the distance *BA* is allowed to represent graphically the unit-stress f_c (not unit-strain) in concrete, *DF* will represent 1/12 of the unit-stress in the steel, or $f_s/12$. This step requires considerable elaboration lest the student, upon finding for f_s a value, let us say, of 12,000 lb. per sq. in., may conclude that the unit-stress in the steel is 1/12 of 12,000 = 1,000 lb. per sq. in.

According to the statement of the problem, concrete is 12 times more elastic than steel, *for stresses below the elastic limit.* A unit-stress which will shorten or lengthen a concrete bar 12/32 of an inch would, if applied to a steel bar of the same size and length, shorten or lengthen it only 1/32 of an inch. Or, if the changes in length of the two bars under stress were equal, the unit-stress in the steel bar would be 12 times that in the concrete bar. Again suppose that the neutral plane were situated 6 inches below the top of the beam, then the unit-strain *BA* in concrete at the top of the beam would equal the unit-strain *DF* in the steel rods, but the unit-stress in the steel would be 12 times greater than the unit-stress in the top layer of concrete.

Now

$$k : 1 - k :: BA : DF :: f_c : \frac{f_s}{12},$$

hence

$$k : 1 - k :: f_c : \frac{f_s}{12}.$$

The total compressive stress on the area $AOGH$ is

$$C = \tfrac{1}{2}f_c \text{ lb. per sq. in.} \times 8 \text{ in.} \times 12k \text{ in.} = 48kf_c \text{ lb.}$$

The steel rods are designed to carry the total tension.

$$T = f_s \text{ lb. per sq. in.} \times 0.96 \text{ sq. in.} = 0.96f_s \text{ lb.}$$

From first principle

$$C = T,$$

$$48kf_c = 0.96f_s,$$

$$f_s = 50kf_c.$$

Therefore

$$k : 1 - k :: f_c : \frac{50kf_c}{12}$$

or

$$k = 0.384,$$

$$AO = 12k = 4.61 \text{ in.},$$

hence

$$OF = 7.39 \text{ in.}$$

The last part of the problem as stated in the text frequently gives a wrong impression to the student. Referring to the definitions of f_c and f_s in paragraph 33 of the text, and then noting in the statement of the problem that $f_c =$ 500 lb. per sq. in., and $f_s = 16,000$ lb. per sq. in., the student frequently concludes that when the top layer of concrete is stressed 500 lb. per sq. in., the steel will simultaneously be stressed 16,000 lb. per sq. in.

Of course, the idea to be conveyed is that the compressive unit-stress in concrete and the tensile unit-stress in steel are not to *exceed* 500 lb. per sq. in. and 16,000 lb. per sq. in. respectively.

Assume that the steel is stressed to 16,000 lb. per sq. in., then

$$4.61 : 7.39 :: f_c : \frac{16{,}000}{12},$$

$$f_c = 832 \text{ lb. per sq. in.},$$

showing that the concrete would be over-stressed.

Assume that the concrete is stressed to 500 lb. per sq. in., then

$$4.61 : 7.39 :: 500 : \frac{f_s}{12},$$

$$f_s = 9{,}618 \text{ lb. per sq. in.},$$

showing that when the concrete has a compressive stress of 500 lb. per sq. in. on its top layer, the steel has a tensile stress of 9,618 lb. per sq. in.

The total compression is

$$C = \frac{500}{2} \text{ lb. per sq. in.} \times 4.61 \text{ in.} \times 8 \text{ in.} = 9{,}220 \text{ lb.}$$

The total tension is

$$T = 9{,}618 \text{ lb. per sq. in.} \times 0.96 \text{ sq. in.} = 9{,}230 \text{ lb.}$$

The slight discrepancy in the values of C and T is due to the fact that the value of k is correct only to three decimals.

The compression C acts 1/3 of $4.61 = 1.54$ in. below the top of the beam, hence the lever arm of the couple is $12 - 1.54 = 10.46$ in.; and the resisting moment is

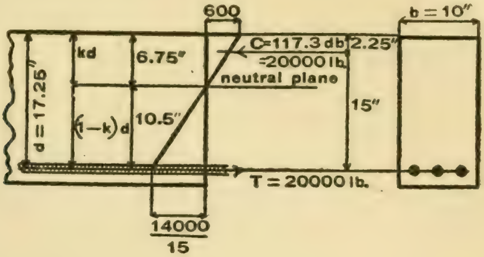
$$M = 9{,}230 \text{ lb.} \times 10.46 \text{ in.} = 96{,}500 \text{ in.-lb.}$$

A figure should be sketched for each problem and reference made to it continually. In this way the student's attention is directed to the problem *per se* rather than to algebraic manipulations.

The following problem is found at the foot of page 57.

Illustrative Problem.—A beam is to be figured to withstand a bending moment of 300,000 in.-lb. A 1:2:4 concrete will be used with $E_c = 2{,}000{,}000$ lb. per sq. in. and $f_c = 600$ lb. per sq. in. The pull in the steel is to be limited to 14,000 lb. per sq. in. Its modulus of elasticity E_s is 30,000,000 lb. per sq. in.

In this problem of design the amount of steel is not given. The neutral plane (Fig. 4) will be so located that the unit-stresses in concrete and steel will reach their respective allowable values of 600 and 14,000 lb. per sq. in. simultaneously. Note that concrete is considered 15 times more elastic than steel.



$$k : 1 - k :: 600 : \frac{14{,}000}{15}$$

or

$$k = 0.391.$$

The compression area is $0.391db$ sq. in. The lever arm is $d - (kd/3) = 0.87d$.

$$C = \frac{600}{2} \text{ lb. per sq. in.} \times 0.391db \text{ sq. in.} = 117.3db \text{ lb.},$$

$$M = 117.3db \text{ lb.} \times 0.87d \text{ in.} = 300{,}000 \text{ in.-lb.},$$

$$102 \text{ lb. per sq. in.} \times bd^2 \text{ in.}^3 = 300{,}000 \text{ in.-lb.},$$

$$bd^2 \text{ in.}^3 = \frac{300{,}000 \text{ in.-lb.}}{102 \text{ lb. per sq. in.}} = 2{,}930 \text{ in.}^3$$

If b is taken as 10 in., then

$$d^2 = 293 \text{ in.}^2 \text{ or } d = 17\tfrac{1}{4} \text{ in.}$$

The lever arm $= 0.87d = 15.0$ in.

$$T = \frac{300{,}000 \text{ in.-lb.}}{15.0 \text{ in.}} = 20{,}000 \text{ lb.}$$

The area of steel required $=\frac{20{,}000 \text{ lb.}}{14{,}000 \text{ lb. per sq. in.}}=1.43$ sq. in.

At about this stage of the course, the impulsive student who was inclined to start a riot when the long-cherished formula was forbidden begins to "sit up and take notice." The emotional and volitional elements in his mental make-up subside and the intellectual faculties rise to the surface. This method at once appeals to the reason, the "noblest function of the mind." He is no longer required to memorize formulas which are too numerous to write upon his cuff.

Some enterprising student will express an interest in the tables and diagrams which appear in the latter part of the text. No explanation is made concerning them except that they contain answers to the problems. This information is sufficient. In a written quiz given near the end of the course, the problems are stated in their most general terms: *i. e.,* symbols are used in place of numerical values, and the formulas are thereby developed. The student is required to make also some addition to the diagrams. For example, in diagram 1, page 223, he is required to add the lines which represent 2,100 and 900 respectively. Throughout the course in design, given the following semester, the diagrams and tables are used continually, although not exclusively.

. . . .

Web Reinforcement.—As the class understands that concrete is not suitable for resisting tensile stresses, the topic of reinforcement for diagonal tension due to shear is easily introduced. There are several ways by which the student may be convinced that diagonal tension exists, whenever he hesitates to put confidence in the mathematical analysis of the lines of principal stresses. The view of a thin web-plate in a girder which has been strained with ultimate loads is an excellent example. The class may observe a small square, which has been drawn upon the edge of a large rubber eraser, distort into a rhombus as the rubber is bent. The subject of equal intensities of horizontal and vertical shearing stress for any point is discussed.

The illustrative problem on page 116 of the text will now be considered and may be stated as follows:

Design a beam to span 10 feet and to support 600 lb. per linear foot (not including weight of beam). The allowable compressive unit-stress for concrete, and the tensile unit-stress for steel are 650 and 16,000 lb. per sq. in. respectively. Ratio of moduli of elasticity is 15.

The allowable bond unit-stress is 80 lb per sq. in.; the allowable shearing unit-stress without web reinforcement is 40 lb. per sq. in., with web reinforcement 120 lb. per sq. in.

Assume 85 lb. per linear foot for the weight of the beam. The maximum bending moment is 103,000 in.-lb.

Make a sketch similar to the diagram in Fig. 4, differing of course in numerical values.

$$k : 1 - k :: 650 : \frac{16{,}000}{15}, \quad k = 0.378.$$

The compression is

$$C = \frac{650}{2} \times 0.378db.$$

The resisting moment is

$$C \times 0.874d = 107.4bd^2 = 103{,}000,$$

$$bd^2 = 960.$$

Assume $b = 7$ inches,

$$d^2 = \frac{960}{7} = 137, \quad d = 11.7 \text{ inches}.$$

We shall design the beam 7 inches wide and 11½ inches from the top surface to the horizontal reinforcing, and allow 13 inches for the total depth. The neutral plane is

$11.5 \times 0.378 = 4.35$ inches below the top of the beam.

The distance between C and T, or what may be called the effective depth is

$$11.5 - \frac{4.35}{3} = 10.05 \text{ in.}$$

The maximum tension is

$$\frac{103{,}000}{10.05} = 10{,}300 \text{ lb.}$$

The steel area required is

$$\frac{10{,}300}{16{,}000} = 0.64 \text{ sq. in.}$$

We shall select three $\frac{1}{2}$-in. sq. bars having a cross-sectional area of 0.75 sq. in. At 150 lb. per cu. ft., the weight per linear foot of the beam is

$$\frac{7 \times 13}{144} \times 150 = 95 \text{ lb.}$$

The assumed and computed weights (85 lb. and 95 lb.) do not differ materially, but we shall assume 696 pounds per linear foot or 58 pounds per linear inch for the total load. The steed area used in the design is about 20 per cent in excess of the amount required; on the other hand we have taken the depth of the beam to the reinforcing as 11.5 inches instead of 11.7 inches. On account of these differences it may be well to review our design.

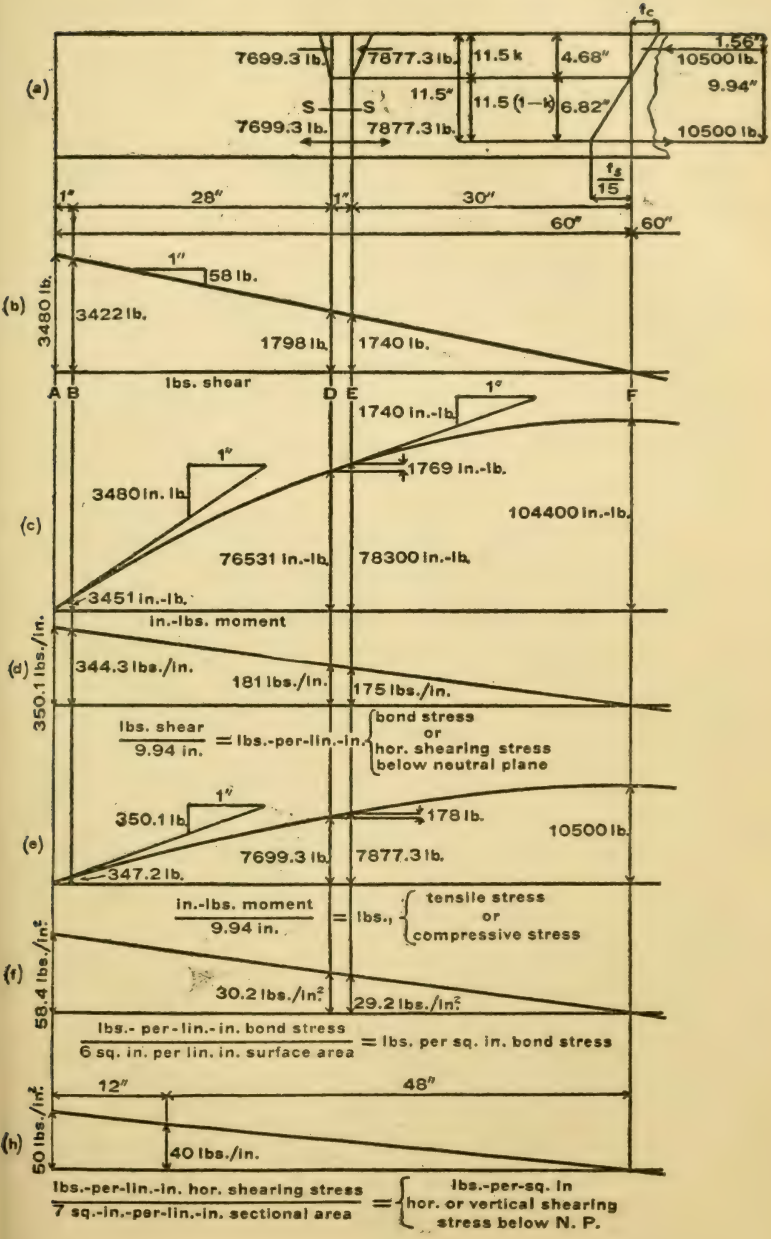
From Fig. 5*a*

$$k : 1 - k :: f_c : \frac{f_s}{15} \text{ or } f_s = \frac{(1-k)15f_c}{k},$$

$$C = \frac{f_c}{2} 11.5k7 = 0.75f_s = \frac{0.75(1-k)15f_c}{k},$$

$$40.25k^2 + 11.25k = 11.25,$$

$$k = 0.407.$$


(a)
7699.3 lb.
7877.3 lb.
11.5 k
4.68"
f_c
1.56"
10500 lb.
9.94"
S
S
11.5"
11.5 (1−k)
6.82"
7699.3 lb.
7877.3 lb.
10500 lb.
f_s/15
1"
28"
1"
30"
60"
60"
(b)
3480 lb.
1"
58 lb.
3422 lb.
1798 lb.
1740 lb.
lbs. shear
A
B
D
E
F
1"
1740 in.-lb.
1"
1769 in.-lb.
3480 in. lb.
(c)
104400 in.-lb.
76531 in.-lb.
78300 in.-lb.
3451 in.-lb.
in.-lbs. moment
(d)
350.1 lbs./in.
344.3 lbs./in.
181 lbs./in.
175 lbs./in.
lbs. shear / 9.94 in. = lbs.-per-lin.-in. {bond stress or hor. shearing stress below neutral plane
1"
350.1 lb.
178 lb.
10500 lb.
(e)
7699.3 lb.
7877.3 lb.
347.2 lb.
in.-lbs. moment / 9.94 in. = lbs., {tensile stress or compressive stress
(f)
58.4 lbs./in.²
30.2 lbs./in.²
29.2 lbs./in.²
lbs.- per-lin.-in. bond stress / 6 sq. in. per lin. in. surface area = lbs. per sq. in. bond stress
12"
48"
(h)
50 lbs./in.²
40 lbs./in.
lbs.-per-lin.-in. hor. shearing stress / 7 sq.-in.-per-lin.-in. sectional area = {lbs.-per-sq. in hor. or vertical shearing stress below N. P.

The neutral plane is

$11.5 \times 0.407 = 4.68$ in. below the top of the beam.

The effective depth is

$$11.5 - \frac{4.68}{3} = 9.94 \text{ in.}$$

The maximum bending moment is

$$\frac{696 \times 10 \times 10 \times 12}{8} = 104,400 \text{ in.-lb.}$$

$$T = \frac{104,400}{9.94} = 10,500 \text{ lb.}$$

At the section of maximum bending moment, the unit-stress in the bars is

$$\frac{10,500}{0.75} = 14,000 \text{ lb. per sq. in.,}$$

$$4.68 : 6.82 :: f_c : \frac{14,000}{15}.$$

Hence the unit-stress in the concrete at the top of the beam is

$$f_c = 641 \text{ lb. per sq. in.}$$

$$C = \frac{641}{2} \times 4.68 \times 7 = 10,500 \text{ lb.} = T \quad \text{(a check).}$$

(Continued.)

A CURIOUS MISNOMER IN MECHANICS.

ANENT THE "CONICAL PENDULUM" AND "CENTRIFUGAL FORCE."

BY ROBERT FLETCHER,

Director of the Thayer School of Civil Engineering, Dartmouth College.

A distinguished, beloved and much lamented former member of this Society once wrote as follows* in criticizing the writer of a text-book entitled "Mechanics for College Students":

> "He is discussing the motion of a conical pendulum whose moving ball describes a horizontal circle. He says:
>
> "'Three forces are acting upon the moving ball: gravitation, the tension in the pendulum-thread or rod, and the centrifugal force which balances the other two.'
>
> "What will become of students who stumble over such a statement as that? Will they ever see clearly that the ball is acted upon by only two forces which do not balance; and that, consequently, the ball is not moving under balanced forces. Centrifugal force is a big bugbear. In the above problem there is no centrifugal force, and there should be no use for the expression."

The erroneous part of this statement was due to the persistence of the author in his idea of looking only at one side of the equation, sometimes averring that we are not concerned with the other body or other side. Consequently the principle known as Newton's third law of motion ("To every action there is always an equal opposite and simultaneous reaction") was systematically slighted. But, of course, in his denouncement of the common conception (or misconception) of "centrifugal force," he was entirely right. There is no such *force* or primary action. It is a *reaction* or resistance which the *inertia* of the body opposes to the incessant deflection from a tangential path. Inertia is not a force but simply a property of the body. By the first law of motion the ball would fly off on a tangent (straight) line, if not constrained by the central force due to the suspending and restraining cord or link.

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* In *Harvard Engineering Journal.*

These elementary considerations are reviewed here because we constantly find in text-books and technical articles statements on this point which at least are hazy and misleading, and sometimes quite erroneous.* The present writer presents the case of the *revolving balls* or Watt governor as follows:

A heavy ball, suspended from a point above by a cord or link, is drawn to one side by a pull, P, acting through a horizontal cord. Here is statical equilibrium of three forces: the weight, W, the tension, T, on the link and the pull, P. The horizontal component of $T = W \tan \theta = P$. The vertical component of $T = T \cos \theta = W$. Now suppose a horizontal impulse is given to the ball so that it revolves around a vertical line, always at a height, h, below the point of suspension and at a constant distance r from the vertical axis; the velocity being such that the aspect (or vertical projection) of the ball and suspending link is the same as before, although P is no longer acting. In this case the equilibrium is not *statical* but *dynamical*. Some deviating action has replaced P; what is it? It is the *centrifugal reaction* which opposes the *centripetal* force, $W \tan \theta$; it has no existence until the latter acts when the velocity of revolution is established; that is to say, it is coexistent but not preëxistent, because no action is possible without an equal and opposite reaction (here the resistance or reaction of inertia).

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* If "to err is human," to be inconsistent is equally human, for all of us. Our genial and revered author, in his excellent textbook, which the writer has used with much satisfaction, has a paragraph farther on beginning with the words "The centrifugal force . . .," in spite of his previous righteous indignation at that term. Of course he constantly deals *with reactions,* while usually avoiding the use of the word.

This brings us to the point of criticism of the term *conical pendulum,* almost universally applied to the revolving ball or balls. In the concepts of mechanics *it certainly is not a pendulum.* It has no property in common with a pendulum, excepting the fact of suspension. The pendulum has variable motion in a vertical plane; an oscillation between opposite points of rest, where the acceleration is a maximum; between which is the lowest point of maximum velocity and consequent zero of acceleration. Per contra the revolving ball has *uniform* motion in a circular orbit. The pendulum is acted upon by the constant force of gravity, while the revolving ball moves under the action of forces in balance—dynamical equilibrium.

Let us note the fact that a heavy weight, held suspended from the hand by a cord, and then made to revolve in its orbit like the ball of the Watt governor (the cord describing a cone), furnishes a simple and beautiful illustration of Newton's three fundamental laws of mechanics. The most obvious is the law of action and reaction (third law, so called) just demonstrated—the centripetal or *central* force and its opposite. The next principle (so-called second law) that change of motion is proportioned to the impressed force and takes place in the line of action of that force—this is most apparent in the normal acceleration, or motion compulsory towards the center, that is change of motion along the radius. This—when a change is forced in the orbital velocity—is felt to be proportional to the central pull or attraction. The first law—that a body always moves in a straight line with uniform motion unless compelled by some force to change that direction or velocity—is indirectly exemplified because the orbital path is possible only through the constraint of the horizontal component of the cord tension, $W \tan \theta$. If we let go the cord, central pull and inertia reaction cease simultaneously, and the body goes off in a tangent plane. Popular misconception on this point appears in the statement that a person is ''thrown out'' of a wagon or automobile. That is a great mistake. When the vehicle suddenly swerves on a sharp curve and the person fails to hold on to the seat, he is not *thrown out* but *left out.* The wagon *leaves him.* He is not *even* left *behind* because he keeps going in the original direction, until he strikes the ground.

When the uniform velocity of revolution of the ball in its orbit is established, evidently *no work is done,* since there is no *change* in the momentum or in the energy. This is not true of the pendulum which is incessantly storing work in its descent and giving up that work against the force of gravitation, in its ascent.

A distinguished writer and teacher* of mechanics gives the following fundamental equation:

$$\Sigma P\delta p - \Sigma m \frac{d^2s}{dt^2}\delta s = 0 \text{ or } \Sigma P\delta p = \Sigma m \frac{d^2s}{dt^2}\delta s,$$

in which P is any impressed force; δp the displacement of its point of application in the direction of P, m the elementary mass acted upon by P, and δs its displacement, while d^2s/dt^2 is its acceleration. Which, being interpreted, is: The algebraic sum of the work of all the impressed forces and of the work of the *reactions* of all the elementary or constituent masses of the body is always equal to zero. Briefly it is an algebraic statement of the third law. Of this he says: ''This single formula is the one fundamental equation which embraces in its discussion the whole of physical and mechanical science.''

Hence those who claim that in mechanics we may consider only one side of the equation and ignore the other side are departing from sound doctrine. It was with regret that the writer (in friendly correspondence only) felt obliged to point out the misconception in regard to the revolving balls, which led to the statement that the forces acting upon them are not in balance. Inevitably the fundamental principle so clearly stated by Bartlett must apply, and be kept constantly in mind. In statics, since there is no change of motion, and no inertia developed, the second term disappears. In dynamics the second term must always enter into the discussion when change of motion occurs.

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* W. H. C. Bartlett, formerly professor of ''natural and experimental philosophy'' at the U. S. Military Academy, West Point, N. Y.

All this is very elementary and may seem impertinent to some readers; but it is a point upon which too little emphasis is placed by some teachers. The writer knows by experience that some students fail to grasp it unless it is reiterated and thoroughly exemplified by problems and illustrative practical cases. We all know how many hazy conceptions and misuse of mechanical terms appear in print. There is need of more insistence upon clean-cut definitions and clear statement of fundamental concepts.

If the term ''centrifugal force'' could be abandoned by common consent and ''centrifugal reaction'' substituted, very much misconception would be avoided. Really there is *never* centrifugal *force* but *always* centrifugal *reaction.* The *''force''* is *centripetal* only.

Certainly it is not justifiable from the point of view either of science or common sense to apply the term *pendulum* to that which has none of the properties of a pendulum according to correct mechanical definition.

DISCUSSION OF "SOME OBSERVATIONS REGARDING THE METHODS OF TEACHING THE THEORY OF REINFORCED CONCRETE DESIGN" BY PROFESSOR A. B. McDANIEL IN ENGINEERING EDUCATION, VOL. VIII, NO. 4, 1917.

BY W. K. HATT,

Purdue University.

Professor McDaniel tells us that the teacher should "utilize every possible device to require the student to exercise his mental processes and shun all rule-of-thumb methods." The present writer has recorded his views concerning the teaching of reinforced concrete design in a paper before the American Concrete Institute, as printed in the *Transactions* for the year 1916, where he has called attention to the difficulty of teaching Reinforced Concrete Design because of the conventional nature of the standard equations which Professor McDaniel uses for the training of the student mind in rational processes.

It is the practise of the present writer to accompany this fundamental theory of reinforced concrete with experiments in the laboratory. For instance, a reinforced concrete beam is tested and the amount of deformation both in the steel and in the concrete is measured by the student who, then, with these deformations and the modulus of elasticity, computes the stresses in the steel and the concrete. He might now apply the Socratic method to Professor McDaniel and ask him how he would explain the fact that whereas Professor McDaniel's fundamental equations would predict a stress of 16,000 pounds per square inch in the steel, the student has measured less than 10,000 pounds per square inch, and why the moment of resistance as computed from the steel stresses at the design load is only 60 per cent. of the external moment.

I think Professor McDaniel would have to explain to the student that the equations and diagrams are conventional and he would have to discuss the stage of flexure at which his equations become representative of facts, before he could meet the needs of an inquiring mind.

The more we bring the student into contact with the real mechanism of physical deformation in actual materials before proceeding to conventions or abstractions, the more likely we are to reach one of the ends of education, namely, to develop power of original thought.

DISCUSSION OF " A NEW POINT OF VIEW IN LABORATORY WORK," BY W. L. UPSON, IN " ENGINEERING EDUCATION," VOL. VIII, NO. 5, 1918.

BY S. A. MOSS,

General Electric Co.

Mr. Upson's general scheme appeals to me very much. I think it has one very important advantage which Mr. Upson does not tabulate. This is the fact that a man who is not fitted to become an electrical engineer probably would not be successful in the sort of laboratory work which is proposed.

I do not believe that a man can be taught to do ''individual creative work'' by an amount of education. A natural aptitude for such work will be disclosed by the course which Mr. Upson gives. I believe, however, that many men will be found who will make no start at all at such work. They will want to know just what they should do next, demand complete directions as to how they should work, remark ''I did not know that is what you wanted'' if specification is made of something they might have done and did not, and so on throughout the well-known list of excuses.

Such men may be perfectly good at other kinds of work, but lack aptitude to do the individual creative work in electrical engineering which Mr. Upson so well discusses. I believe the cases Mr. Upson mentions of lack of enthusiasm are really lack of aptitude. It seems to me that it can never be developed or ''instilled'' in such cases.

It seems to me, therefore, that such laboratory work could easily be made a deciding factor as to whether or not a man is fitted to become an electrical engineer. Such a laboratory course is of course admirable for a man who can succeed in it.

It cannot produce the ability to do ''individual creative work," but it can develop such ability when it previously exists. If a man fails in such a course it will probably be because he lacks creative ability in this direction. He should then be directed to some pursuit other than electrical engineering.

BY BARRY MacNUTT,

Lehigh University.

Professor Upson's article in the January *Engineering Education* was read with a great deal of interest and pleasure. He has unquestionably the right idea and it is gratifying to find someone who has broken away from the traditional laboratory methods which have so devitalized laboratory work in colleges and technical schools.

A few years ago I tried the experiment of conducting our sophomore laboratory course in physics, covering Mechanics, Heat, Electricity, Magnetism, Light and Sound, in a manner very similar to Prof. Upson's. Instead of giving the students a fixed number of experiments per term, with cut-and-dried directions as to exactly how they were to perform each experiment—the apparatus required, diagram of connections, work to be done, number of observations necessary, etc. (thus relieving the student of all necessity to think)—we gave them a series of "problems" to be solved in the laboratory. Some of these "problems" were as follows:

Locate the center of mass of this belt pulley.

Standardize this aneroid barometer.

How much heat per day is absorbed by the refrigerator in the laboratory?

Determine the eutectic point of sugar.

Find the efficiency of an electric heater for heating water.

How much of a temperature drop outdoors today would be required to condense some of the water vapor in the air?

Find how long a piece of this wire would be required for a resistance of 1,000 ohms at 20° C.

Construct a shunt for this galvanometer, so that it will be one tenth as sensitive, etc.

The students were given these ''problems'' and turned loose in the laboratory where they were given, within limits, as much time as they desired to solve them. The sections numbered from sixteen to twenty men per instructor.

The experiment was not altogether successful. We found that students of sophomore age were not mature enough (with a very few exceptions) to profit by a course in which there was no rigorous constraint. They did not take sufficient interest in the course to try to get all out of it that it contained and their work tended towards slovenliness and ''soldiering.'' It did, however, make them think for themselves, so that the course cannot be said to be an entire failure.

In our Sophomore Laboratory Course we have gradually slipped back to a compromise between the above revolutionary method and the cut-and-dried formalism of the typical physics laboratory course.

At present, the Sophomores are held to a definite number of experiments per term but the notes on these experiments are cut down to a minimum, and the students are made to rely on their own resourcefulness as much as possible. They do not, perhaps, have to think for themselves quite as much as they did, but they are more industrious and possibly learn better to be precise and methodical.

For some time I have been considering the advisability of trying the revolutionary method in our junior course in advanced electrical measurements. Professor Upson's article has decided me to run this course according to the method he pursues at Union College.

COMMITTEE ON EDUCATION AND SPECIAL TRAINING.

The Committee on Engineering Education of the Council of National Defense recommended to the Secretary of War, on August 17, the creation in the War Department, of a board to take charge of the technical training of enlisted men. The matter was referred by the Secretary to the General Staff and Capt. Lane assigned to work with the committee in regard to it. The matter was under consideration by the General Staff for a number of months. Upon February 13, the Secretary of War authorized the following announcement:

''With a view to mobilizing the educational institutions of the country and their faculties for special training, there has been created in the War Department a 'Committee on Education and Special Training.'' Associated with this committee will be five civilian educators, known as an advisory board of educators.

''The committee will be composed of Col. Hugh S. Johnson, deputy provost marshal-general; Lieut. Col. Robert I. Rees, of the General Staff; and Maj. Grenville Clark, of the Adjutant-General's Department.

" Advisory Members of Committee."

''The five advisory members of the committee, whose selection has been approved by the Secretary of War, are:

''Dr. Charles R, Mann, of the Carnegie Foundation for the Advancement of Teaching, and the Massachusetts Institute of Technology.

''Dr. James R. Angell, of Chicago, dean of the faculties of the University of Chicago.

''Mr. J. W. Dietz, of Chicago, director of education, Western Electric Company, president of the National Association of Corporation Schools.

''Mr. James P. Munroe, of Boston, a member of the Federal

Board for Vocational Education (which appointment will include the interests of the trade schools and schools of secondary grade).

''Dr. Samuel P. Capen, of Washington, specialist in higher education.

''In these appointments it is felt that the entire educational field has been covered, since Dr. Mann is representative of engineering schools, Dr. Angell is representative of academic colleges and universities, and Mr. Dietz is from the field of schools conducted by industrial concerns. The committee will be authorized to call in from time to time other educators for consultation and assistance.

"Functions of the Committee.

''The functions of this committee will be to mobilize the country's schools and colleges behind the Army. It will encourage and arrange for the technical education of men needed by the several branches of the Army, particularly the Ordnance Bureau, the Signal Corps, and the Engineers. In a degree the educational institutions are already rendering patriotic service to the government, but it is planned that there shall be a systemization of their efforts and that their facilities for technical training shall be fully utilized.''

Delayed Classification of Instructors.

The following telegram was received by the Secretary of the Society in reply to a request for exact information in regard to instructors in the special technical courses being given to soldiers under the direction of this committee:

''Instructor certified by institutions engaged in war work as essential to carrying on the work may enlist in Enlisted Reserve and be placed in Class V when his application and certificate are approved by this Committee.''

''(signed) C. R. Mann.''

TWENTY-SIXTH ANNUAL MEETING AT NORTHWESTERN UNIVERSITY, EVANSTON, ILL., JUNE 26–29.

REGISTRATION AND INFORMATION.

The place of registration and general information in connection with rooms, meals, baggage, etc., will be in one of the dormitory buildings. The general registration, post office, etc., will be in Swift Hall of Engineering.

MEETING PLACE.

All meetings of the Society will be held in the main lecture room Swift Hall of Engineering. Meetings of the Council and all committees will be held in adjoining rooms.

MEALS.

Meals will be served in the dining rooms of certain of the fraternity houses.

RECREATION AND EXCURSIONS.

The dormitories and fraternity houses at which members are to live and Swift Hall of Engineering at which the formal meetings of the Society will be held are all on the shore of Lake Michigan in well-shaded grounds. The Local Committee hopes that its guests will, as a rule, use the late afternoon hours to get acquainted with each other in the open air on the shore of the lake and the Committee will endeavor to make it pleasant for them to do so. There will be opportunities for swimming and other out-of-door activities. As indicated in the program there will be an informal meeting at the Gymnasium on Wednesday evening and both the afternoon and evening of Friday will be devoted to an excursion on the north shore and a dinner at one of its most pleasant resorts, Ravinia Park.

The following announcements should be inserted in the proper places in the program.

Wednesday, June 26, 8:00 p.m. Annual Mixer Meeting at the Northwestern Gymnasium.

Friday, June 28. The afternoon will be devoted to an excursion by electric cars to the United States Naval Training Station at Great Lakes, Ill. On the return trip a stop-over will be made at Ravinia Park for the annual dinner of the Society at 6:30 p.m., to be followed by the presidential address and other speakers.

General Committee: Director John F. Hayford, Chairman, Professors H. S. Philbrick, O. H. Basquin, W. C. Bauer.

Committee on Rooms and Meals: H. S. Philbrick, Chairman, W. C. Bauer, W. F. Bryan, K. K. Smith.

Committee on Relations with Non-Members and Entertainment of Visiting Ladies: O. H. Basquin, Chairman, H. S. Philbrick, W. F. Bryan.

Committee on Arrangements at Swift Hall of Engineering: John F. Hayford, Chairman, W. H. Burger, K. K. Smith, M. R. Hammer.

Committee on Afternoon Excursions and other Social Affairs: W. C. Bauer, Chairman, W. H. Burger, K. K. Smith.

EDITORIALS.

The Report of the Joint Committee on Engineering Education.—We understand that the report of the Joint Committee on Engineering Education, which was appointed through the efforts of this Society in 1907, is now in the hands of the printers and will be available for distribution before the annual meeting. This report is the outcome of a long study of engineering schools. It has been discussed at our annual meetings by Dr. C. R. Mann, the investigator in charge. The completed report will undoubtedly call forth much discussion and favorable comment. It forecasts the type of engineering schools best adapted to meet the needs of this country in the training of engineers and representing, as it does, not only long years of study, but the efforts of many men, it should be recognized as an authority and point the way to the advancement and development of engineering education during and after the war.

A Curious Misnomer in Mechanics.—Director Robert Fletcher of the Thayer School of Dartmouth College has, in this number of ENGINEERING EDUCATION, an interesting article on "A Curious Misnomer in Mechanics." There is more in the article than appears in the title since it is also an exposition of the necessity for greater clearness and more appropriate use of terms in mechanics. The following quotation should be taken to heart by all teachers of engineering students:

"We all know how many hazy conceptions and misuses of mechanical terms appear in print. There is need of more insistence upon clean-cut definitions and clear statements of fundamental concepts."

PERSONALS.

Mr. Milo S. Ketchum, President of the S. P. E. E., dean of the college of engineering, University of Colorado, has been granted a leave of absence by the regents of the university to accept a position as an assistant director, acting under Mr. D. C. Jackling, director in charge of the construction of U. S. government explosives plants.

Dean Ketchum will be located at Charleston as assistant director in charge of the construction of the explosives plant that is being constructed near that place. His address will be U. S. Government Explosives Plant "C," Nitro, West Virginia.

COLLEGE NOTES.

Throop College of Technology of Pasadena has adopted the following important plans with a view to increasing the effectiveness of the College in war work:

1. The introduction of a course in ship construction and ocean transportation to be required of all juniors and seniors in the college. This course will be inaugurated by Professor Frank P. McKibben, of Lehigh University, now serving under the United States Shipping Board. The course will be supplemented by visits to shipyards in Los Angeles harbor.

2. The speeding up of the work of the present senior class and setting forward the date of their graduation from June 4 to April 7.

3. The speeding up of the work of the present junior class continuing their instruction through the coming summer, and graduating them September 15, 1918, instead of in June, 1919.

4. The admission of a special freshman class on February 4, 1918, and continuing their instruction through the summer so as to give them a year's work by the opening of the fall semester, 1918, at which time they will become regular sophomores. It is anticipated that a good-sized class will enter at the mid-year.

BOOK REVIEWS.

Mathematical Tables for Classroom Use. By MANSFIELD MERRIMAN. First Edition. John Wiley and Sons, 1915. 5 × 7½. 67 pages.

These four-place tables have been taken from the American Civil Engineers Pocket Book and will be useful to the student in shortening his time spent in laborious computations. In this small volume are found thirty-five tables with the explanations for their use and with remarks on the degree of precision to be expected in interpolated tabular values.

F. A. F.

Infinitesimal Calculus. Section I. By F. S. CAREY, Professor in the University of Liverpool. Longmans, Green and Co. 1917. 5½ × 8½. Cloth. 144–xiv pages.

The ideas of range and sequence have been introduced early in the book and used throughout. The notation of single and fully barbed arrows is used to express the limits of sequences with a careful distinction as to their respective uses. The book will be found rich in suggestions to the teacher who wishes to see these methods applied to an elementary textbook.

F. A. F.

Theory and Operation of Direct Current Machinery. By CYRIL M. JANSKY, Associate Professor of Electrical Engineering, University of Wisconsin. McGraw-Hill Book Co., Inc. 1917. 6 × 9¼. 285 pages.

This book is suitable for persons who wish to gain a broad knowledge of the principles and operation of direct current machinery in the shortest possible time. About equal space is allotted to the following phases of direct current machinery: the fundamental theories and elements underlying direct current apparatus, the construction of generators and motors with the theory upon which the construction depends, and the operation of generators and motors. Chapters pertaining to special applications, batteries automatic starters, etc., as found in most electrical texts, are omitted. The entire book is devoted to direct-current dynamos. It gives the reader a very plain and elaborate presentation of direct current machines with the involution of only elementary mathematics.

J. E. K.

Kinematics of Machinery. By ARTHUR WARNER KLEIN, M. E. Professor of Mechanical Engineering, Lehigh University. McGraw-Hill Book Co. Inc. 1917. 6 × 9, 227 pages. Cloth.

The major part of this book deals with the graphical method for the solution of machine kinematics. The explanations are clear and fully developed. Numerous illustrations assist in making the subject plain to the student.

Those points which have been deemed unnecessary for an elementary course are omitted from the text proper and grouped in an appendix.

It is a book equally valuable to both the student and practising engineer.

W. E. J.

Position Wanted.—931. Teacher of Electrical Engineering desires change after July 1.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

Milo S. Ketchum, G. R. Chatburn, F. L. Bishop, *Editor*.

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A MOVEMENT FOR GREATER RECOGNITION OF SCHOLARSHIP.

Report of a Committee of the Cornell University Faculty on the Alumni Inquiry Regarding the Recognition of Scholarship.

The question which this committee was instructed to consider was first raised by the board of directors of the Associate Alumni, when, on March 31, 1916, it voted to offer to the faculty the assistance of its organization in securing recognition for unusual excellence in scholarship on the part of students of the university and asked the faculty to suggest means whereby such recognition could be made most effective. This committee was appointed by the faculty to consider the question thus raised and to recommend such action as might form a suitable response to the inquiry from the alumni.

A. Suggestions for Action by the Faculty.

1. The committee recommends that an annual convocation of the members of the university be devoted, at least in part, to the recognition of academic honors. Such an assembly was first suggested by Mr. Hoy. At present, academic honors are officially noted only on the commencement programme, for the benefit of the graduating class and its friends. Athletic distinctions, on the contrary, are awarded with impressive ceremony, before a representative student gathering. The committee believes that we owe it to the recipients of academic honors to give formal recognition to their achievements. At the convocation proposed an address might well be given by a distinguished speaker, who, if possible, should be an alumnus of this university. The committee originally contemplated, as an appropriate date for such an assembly, the day of the meeting of the board of trustees in April; but two objections to this

arrangement have been offered: (*a*) the trustees already have rather a busy day, and (*b*), as Professor Keniston suggests, it would be too late in the year, if the occasion is to impress the students and especially the freshmen with a realizing sense of the opportunities of which they may and should take immediate advantage. At Harvard the "Award of Academic Distinctions" is held early in the year and is said to have had an excellent influence on new students. Possibly this precedent might be followed, or, as the committee is now prepared to recommend, the proposed recognition of academic honors could be given on Founder's Day. This might be sufficiently early, there would be more time for the speaker of the day, and the honor which we owe to the memory of the founder of the university would be appropriately combined with the recognition of those who had proved their right to profit by his devotion and by the generosity of their other benefactors.

2. The committee recommends that the faculty give recognition, at such an occasion as has just been suggested or in some other manner, to those students who are honored by election to Phi Beta Kappa, to Sigma Xi, to Tau Beta Pi, or to any similar society.

3. The committee recommends that the faculty request its special committee on prizes to consider and report upon means whereby those prizes which appear to be commonly neglected may be made more effective incentives to intellectual effort.

4. The committee recommends that the university faculty recommend to the several college faculties the institution, if possible, in each college, of an "orientation course" for freshmen. Such a course might cover such topics as these: the nature of a university; the history, organization and characteristics of Cornell University; your college and its work; the work of the other colleges; the University Library; undergraduate life; how to study and how to make the most of your mental apparatus and of your academic opportunities; how to improve your physical condition; how some great men were educated; some scientific and social problems that await solution; the

choice of your vocation. Orientation courses of this general character are now given at several colleges and universities and appear to have proved their value. With us the freshman is ''orientated'' by upperclassmen, by the athletic authorities, and at ''get-wise'' meetings in some of the colleges and at Barnes Hall. The committee is indebted to Professor Burr for a copy of the syllabus for the orientation course at Brown University, which will be submitted to the inspection of the faculty.* The committee hopes that, if similar courses are undertaken here, they will not consist merely of lectures, but that an effort will be made to elicit ideas from the freshmen themselves.

5. The committee transmits to the faculty for transmission to the several college faculties the suggestion that in each college honorary undergraduate scholarships, without stipend, be annually awarded on the basis of scholastic rank.

6. The committee transmits to the faculty for transmission to the several college faculties a proposal to recognize honor groups, consisting of the best students in each class in each college, whose names could be published in the University Bulletin and announced at the proposed convocation on Founder's Day.

Further than these recommendations, so far as formal action by the faculty is concerned, the committee is not at present prepared to go; but certain other suggestions and opinions have been laid before it which seem worthy of consideration on the part of members of the faculty.

We have received from Mr. George H. Ashley, of the class of 1889, in a letter appended to this report, the suggestion that, in addition to credits for quantity, secured by attaining passing grades, additional credits for quality be required of all students.

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* The rules for the course at Brown and a list of lectures for the current year are printed at page 28 of this report. The course is described by Professor W. H. Kenerson in the BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, Vol. VI (1916), pp. 423 ff. A similar course at Reed College is described in the *New York Times* of April 15, 1917.

We have received from Professor Davenport a communication also appended to this report, outlining a new plan for the standardization of marks.

Professor English suggests that a student who has been put on probation should not be allowed to take part in extra-curricular activities until he has completed, after the expiration of his period of probation, an entire term in good standing.

Professor Keniston suggests a system of ''degrees with distinction,'' to be recognized on the commencement programme and on the diplomas of those students to whom such degrees are granted. Professor Karapetoff makes a similar recommendation.

Several of our correspondents have suggested action to be taken with reference to fraternities: that no fraternity should be allowed to admit a freshman until after he has spent one term at the university; that no student be admitted who is on probation or who has not received marks of a certain grade; that fraternities whose records are poor be subjected to certain restrictions; that every fraternity be required to have two alumni members living in the house. Professor Kimball says that he has ''always been much impressed with the lack of interest shown by members of our own faculty in the affairs of their own fraternities,'' and believes that ''most of the evils of the campus could be reformed quickly if every member of the university faculty would try to do what really is his duty in connection with the group of students with which he is thrown in most intimate contact.''

Several members of the faculty and several of the students whose letters are included in the appendix have recommended the institution of ''courses for honors,'' to which those students would be admitted who had shown marked ability and upon admission to which they would be relieved of certain requirements and entitled to certain privileges. This suggestion was offered originally by a group of seniors in the college of arts and sciences and has now been approved by the faculty of that college; but it may be that the idea also deserves attention in other colleges in the university.

It will be noted that several of our student correspondents put the responsibility for the undergraduate attitude toward scholarship squarely up to the faculty; and also that Dean Thilly, in a hitherto unpublished extract from his report to the president for last year, urges the members of the faculty to set their own house in order.

The committee has observed numerous indications of a widespread conviction that the faculty should take more effectual action for the exclusion of those students whose ability or whose ambition does not justify their membership in the university. It is generally recognized that the presence of these ''non-conductors'' lowers the tone of the whole body and that they are present in considerable numbers; but however directly this situation bears upon the problem of student scholarship, the committee has not felt warranted in attempting to discuss it.* Each of the college faculties now has full power to excuse from further attendance students who might better be spending their time elsewhere. The question of a change in our method of admitting students has been referred by the university faculty to another committee. We venture, however, to call attention to the circumstance that at Reed College no candidate is ordinarily admitted who has not ranked in the first third of his class at school. It is clear that a distinction of this kind, might be applied to students entering by examination or on regents' certificates as well as to those who present school certificates, and that admission to the university might thus be put on a competitive basis. The *Alumni News*

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* Four significant contributions to the discussion of the question have appeared in the *Alumni News:* Professor Davenport's address on ''The Depreciating Dollar and University Policy,'' in the number for February 1; Dr. van Loon's article, ''No Compromise!'' in that for March 1; Professor Willcox's letter to the committee (see p. 22) in that for March 8; and Professor Keniston's article on entrance methods in that for March 22.

(February 15, 1917) assures the faculty that the alumni will not complain if a maintenance of real university standards shall cause a reduction in the size of the university; and Mr. R. W. Sailor writes to the committee: ''To produce real scholars from the undergraduate body, it is necessary, it seems to me, to have a faculty composed of scholars and to weed out the delinquent students to as great a degree as is necessary to give a scholarly faculty sufficient time, by freeing them from unnecessary work in trying to educate uneducatable students, so that the faculty composed of scholars can impress its scholarship on the remaining students.''

The committee has also found evidence of a general impression that, under existing conditions, an excessively large amount of instruction is given by inexperienced and inexpert teachers.* It is apparent that this is a matter which is forcing itself upon the consideration of university authorities elsewhere. A Cornell alumnus, Professor J. A. Leighton, of The Ohio State University, in an article on ''Democracy and Intellectual Distinction'' in *School and Society* for April 14, 1917, alleges that college and university chairs in America are being manned largely by mediocre men and that the increase in the number of students is commonly met ''by hiring cheap and untried instructors to teach an ever-multiplying and bewildering variety of courses.'' As for Cornell, the committee has heard of one freshman who informed his father that most of his teachers during the year had not seemed really interested in their subjects and, on the other hand, of another student, who, after a year at another university, came back to Cornell, because there he would be taught only by young instructors, while here he would be taught by professors. With reference to this very serious problem, an interesting suggestion has been offered to the committee by Mr. Sidney P. Howell, a member of the present senior class, himself an assistant in history. ''I believe,'' says Mr. Howell, ''that professors ought to spend more time with the freshmen than with any other class save perhaps the seniors. How can you expect these poor lads who have no idea how to work to accomplish anything under instructors and student assistants whose knowledge after all isn't much greater than that of the freshmen? How can you improve your scholarship if you have no foundation upon which to build? Even now, the freshman year safely past, the sophomores and juniors know how to attack, but the lack of proper experience handicaps them throughout their course, and they attack less effectively, on the whole, than they might. Given the proper supervision while learning the new process, less experienced teachers might easily guide them through the middle years with as great success as the best, because, the process once learned, it is up to the student rather than to the teacher to produce results.''

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* The direct relation between the recent increase in the number of students and the decreased proportion of professors and assistant professors to the whole number of teachers is brought out very clearly in a table published in the *Alumni News* for March 8, 1917. ''Some way,'' says the *Alumni News* (p. 258), ''must be found to check the University's horizontal growth until it has become able to build itself up.''

While it is probable that members of the faculty have commonly regarded the problem thus indicated as insoluble except through a large increase in the endowment of the university, for which they must look to the trustees and the alumni, it is the opinion of Mr. Newman that the initiative for any considerable improvement must come from the president and the faculty. Similarly a member of the faculty, Professor Cooper, suggests the appointment of a committee to consider the best methods of securing new members of the teaching force. ''Far too many classes,'' says Professor Cooper, ''are like cadavers undergoing dissection at the hands of neophyte surgeons.''

The committee feels considerable sympathy with the younger members of our teaching staff at whom so much unfavorable criticism has been levelled. They have been encouraged to undertake work to which they have been told that they were equal. In the criticism to which they have been subjected they may at least find an incentive to show what they can do. Perhaps they have a right to expect more guidance than they now often receive. Perhaps more adequate provision should be made for their training as teachers. When, however, the committee in its request for advice suggested ''lectures on methods of teaching'' for members of the instructing staff, the proposal elicited an unfavorable reaction from almost all the professors from whom the committee has heard. In this form the suggestion appears to have been unpalatable. Surely, however, most members of the faculty continually subject themselves as teachers to self-criticism and do their best to profit, as teachers, by their own and by others' educational experience. Surely teaching is an art that has, like other arts, a foundation in theory. Surely, neophyte teachers as well as neophyte surgeons may be helped by instruction from those who have more completely mastered this difficult art. The committee has no thought of depreciating the importance of productive scholarship as a prerequisite for successful teaching in a university. We agree with Professor Cooper when he maintains that in the long run the best scholars are the best teachers. We agree with Mr. Hoy when he says: ''What an instructor who does not know his subject would get out of lectures on teaching is beyond me.'' Whether Mr. L. V. Heilbrunn, of the class of 1911, is correct in thinking that what we most need is more inspiring teaching, or whether a member of the class of 1915 is justified in his criticisms of the faculty published in the *Alumni News* for April 12 and included in the appendix of this report, the committee will not attempt to say; but it is prepared to express the hope that we who are so prone to criticize others will not refuse to entertain criticism of ourselves. The committee will not go so far as to indorse the opinion of Mr. R. W. Livingstone, of Corpus Christi College, Oxford,* that ''no one should teach who has not studied the theory of teaching''; nor will it recommend the institution of such a series of talks to instructors as has been given at the Iowa State

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* In his latest work, ''A Defence of Classical Education,'' p. 270. The whole passage is quoted at p. 43 below.

College on "Teaching How to Study," "The Laws of Memory," "The Conduct of Recitations," "Good Questioning" and similar subjects; nor will it advise any department to follow the precedent set by the department of economics at Harvard when it invited the sister department of education to investigate the undergraduate instruction in economics with a view to its improvement;* nor will it recommend that any of our colleges imitate the procedure of the Massachusetts Institute of Technology in appointing a faculty committee on methods of instruction, under a chairman who will devote his entire time to the work for three years, with special reference to the problem of preventing an overcrowded curriculum and to that of securing the proper training of instructors.† The committee will go no further than to call attention to these facts and also to an article by one of its members, Professor Jacoby, on "Some Details in Engineering Education" (in the Proceedings of the Society for the Promotion of Engineering Education, Vol. 24, 1916) in which certain pedagogical questions with which all university teachers have to deal are discussed and reasons are given for the belief that, under existing conditions, it is desirable for a technical college or the university of which it forms a part, to make an organized effort to improve the teaching power of its instructors.

One specific improvement in our practise is recommended to the committee and to the faculty by professors who believe that too much of our instruction is given in the form of lectures. They agree with Socrates. "The lecture system," says Professor Willcox, "under-values the class as a social group and the educational stimulus and value of the interactions between its members." "There is too little self-activity," says Professor Cooper "on the part of the student, who does not like to be passive (though he is willing to be entertained) and naturally turns to the 'student activities,' in order to find something to do that he deems worthy of a man with a backbone." "The interest of students," says Professor Winans, "would be much quickened, if each department would turn its attention to working methods by which the student could more often experience the joy of accomplishment, and could bring that accomplishment before his fellows, to be fought over perhaps, and not merely submit it to an instructor." "Every difficult problem in mechanics or in electricity," says Professor Karapetoff "should be a community problem for the class, and not an individual problem for Mr. Jones."

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* See President Lowell's report for 1915–16.

† Cf. *The Engineering News-Record,* April 5, 1917, p. 58.

It seems to the committee that, so far as individual or corporate action by members of the faculty is concerned, no better formulation of its general conclusions could be found than the words in which a member of the senior class, Mr. Bertram F. Willcox, sums up the whole matter: "If college work could be made competitive and interesting and social, surely the students would respond by making it honorable."

B. Suggestions for Action by the Alumni.

Addressing itself now to the alumni, upon whose initiative this whole inquiry has been undertaken, the committee would be glad, if it could, to give adequate expression to the gratification with which the faculty welcomes the expression of their concern for the higher interests of the university. We believe that their devotion to their alma mater and their gratitude to her founders and benefactors, to the national government, and to the state, could take no more substantial or impressive form than this. We believe that the alumni have an opportunity, the significance of which we are only just beginning to realize, to aid in effecting that change in the mental attitude of many of our undergraduate students, in which we recognize the necessary condition for the real vitality and the true success of the university. Such a change will not come over night; the influence of the alumni must be exerted during a long series of years and for generations to come.

The university, as we all know, cannot do its work without the financial assistance of its alumni, to whose loyalty and liberality it owes indispensable and increasing additions to its resources. An alumni fund amounting to $100,000 a year, the immediate goal of the Cornellian Council, would be equivalent to the income from an endowment of about two millions. Other universities are receiving additions to their productive funds on a similar or a larger scale. Some state universities in the West and some of the older endowed universities of the East are forging ahead more rapidly than we are. If Cornell it to live up to its traditions and to meet its opportunities, if it is to maintain a large faculty of real scholars and real teachers, if its library is to hold its place secure among the great libraries of the country, if it is to be adequately equipped with buildings and educational appliances, if it is to continue to be a first-rate, a many-sided and a large university and not to become a second-rate, a lop-sided or a much smaller university that at present, it must have all the money than its alumni can give or induce others to give; but this is not the only thing nor possibly the most important thing that they can do for Cornell. Size or prominence is not essential to the greatness of a university. We can still be a first-rate univesity on a modest and restricted scale. A great city, as Aristotle said, is not a big city but one that does its work well. "Though I bestow all my goods to feed the poor," said St. Paul, "and though I give my body to be burned and have not charity, it profiteth me nothing." The charity of which the university is most in need is love for its spirit, devotion to its higher life, intelligent concern for the vital interests of its youthful members who come to us while they are still "wax to receive and marble to retain."

Without this, all else is of little worth. The contributions which the alumni are making to the material resources of the university will yield their full proceeds only if they shall be accompanied and sustained by contributions to its spiritual resources. Let the alumni think of themselves as still active members of the university, as students of a higher grade. The aim of education, we are told, is merely more education. Its test, we all believe, is to be found in capacity to make discoveries, to discern new relations, to solve problems. It is a social adventure. There are departments of the university many of whose graduates remain in mutually fruitful intellectual contact with their former teachers. They continue to exchange ideas with one another. In an ideal university, once a student would mean always a student. Let us try to approximate to this ideal. An alumnus who continues to draw form the university inspiration and information and to put at its disposal the results of his own investigation and experience will be in a more favorable position to help his successors during their undergraduate days than one who has ceased to regard himself as a student, who is merely a regular subscriber or a casual visitor, reminiscent of the past.

If any alumnus earnestly desires to do something to encourage unusual excellence in scholarship among the undergraduates, but does not see just what he can do, we venture to suggest that he might possibly find it helpful to read, in the first place, John Erskine's essay on "The Moral Obligation to be Intelligent," for the sake of its well-sustained plea that what America needs is more knowledge; and in the second place, a little book entitled "Should Students Study?" by President W. T. Foster, of Reed College, for the sake especially of its well-balanced argument in support of the thesis that the students who do high-class work in school are generally those who do high-class work at college, and that those who do high-class work at college are generally those who do high-class work later in life.* Then let him read, if he has not yet read, the chapters in "The Autobiography of Andrew D. White," which tell the story of the foundation and the early years of Cornell University, that he may become personally acquainted with the aspirations and the sacrifices that were built into its fabric. Let him get into touch, either in the course of a visit to the campus or by correspondence, with the present work and the present problems of one or more departments of the university. And then let him get hold of some student in whom he is interested and talk to him about it all and draw him out.

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* President Foster shows for instance, on the evidence of statistics, that not one man in twenty years who was satisfied in Harvard College with grades of C and lower gained distinction in the studies of the Harvard Law School; that from the records of 1667 graduates of Wesleyan University, it is apparent that at that institution, of the highest-honor graduates (two or three in each class) one out of two will become distinguished, of Phi Beta Kappa men, one out of three, of the rest, one out of ten; that it is likely that the first quarter in scholarship of any school or college class will give to the world as many distinguished men as the other three quarters; and, in short, that the success of the undergraduate in his formal intellectual education is the safest single measure—

We lay stress upon this individual work because we believe that, in the long run, it is the kind that will count most. We suggest that the board of directors of the Alumni Association might well study its possibilities and take such action as may be feasible toward meeting more and more fully what we believe to be the desire of an increasing number of our alumni to keep in touch with the university and its work and to give time and attention to its necessities. A sustained effort might be made to promote such missionary activity on the part of earnest and well-informed alumni as we have suggested; and through the secretary of the Association Alumni and the secretary of the university the alumni organization might bring an increasing number of its members into personal contact with the university of to-day and of to-morrow and with successive generations of students.

Another opportunity for personal service on the part of alumni would, we believe, be afforded, if the several college faculties or any one of them should receive with favor the suggestion that orientation courses be provided for freshmen. An occasional address by an alumnus in such a course would stimulate interest and contribute useful information. Should orientation courses be instituted, we trust that the faculty committees in charge will desire and receive the coöperation of the alumni organization in arranging for talks by alumni.

though not the only measure—of the success he is likely to achieve in later life.

Even if no orientation courses should be instituted, there would still be room for such talks. No lectures given in the university have proved more useful and helpful than those in the course on citizenship, which was originally suggested and year after year has been arranged by a committee of alumni engaged in social service. Among the lecturers in this course have been a number of alumni, and they have given us, what speakers from the outside world can but do not always give, not pious generalities, but concrete information and specific lessons of experience. If the faculty should institute a convocation for the recognition of academic honors, we hope, as has been intimated above, that the speaker on that occasion would ordinarily be an alumnus of the university.

If, furthermore, the faculty should be of the opinion that the time has come to make a more definite appeal to the competitive instinct in the field of scholarship, there would be an opening for the establishment by individual alumni or by groups of alumni of prizes or of funded scholarships in each college. In some of the colleges such prizes might be awarded under conditions similar to those prescribed for the Boardman and the Fraser scholarships in the college of law. The Boardman scholarship is a prize of $100, awarded annually in June to the student who has, in the judgment of the faculty, done the best work in law subjects to the end of his junior year. There are two Fraser scholarships, of the value of $100 and $50, respectively, and these are awarded to seniors who have most fully evidenced high qualities of mind and character by superior achievement in scholarship and by those attributes of manliness which earn the commendation of teachers and fellow students. The award is made upon recommendation of the senior class by vote from a list of candidates submitted by the faculty as eligible by reason of superior scholarship. These prizes elicit keen competition. There is similar competition for the Fuertes medal, awarded annually to that student in the college of civil engineering who is found, at the time of graduation, to have maintained the highest scholarship in the courses of his college. Evidently we have in each of these instances what Professor Willcox would call a social group in action. Such a group in the college of arts and sciences or in the college of agriculture would be found not in the senior or any other class but in those who are specializing in one subject or in a group of kindred subjects; and if prizes are to be given in those colleges, they should be put at the disposition of separate departments or groups of allied departments.

It is only fair for the committee to mention that Mr. Tatum, who first made to it the suggestion that alumni prizes for high scholarship might be established, coupled with this the proviso that, in awarding such prizes, consideration should be given not only to high class standing but also to success in other activities. It is also only fair to say that the committee has found general reluctance, among those who have given it their advice, to accept this proviso. The general opinion seems to be that sufficient recognition is already given to extra-curricular activities. In leaving the final decision to the candidates' fellow students, the rules governing the award of the Fraser Scholarships would appear to give an opening for sufficient recognition of qualities of mind and character which may not necessarily be revealed in the class-room.

The committee suggests to the board of directors of the Alumni Association that it may well consider the advisability of encouraging the establishment, under suitable conditions, of prizes for high scholarship, or even, as Mr. Sailor has suggested, of recommending the establishment of such prizes by the Associate Alumni.

The alumni might particularly consider the advisability of taking steps to increase the number of university undergraduate scholarships, offered each year to members of the incoming freshman class. There are now, under normal conditions, about 1,350 freshmen, and there are only eighteen of these scholarships. Each has an annual value of $200, but the recipients, except those from New York state registered in the state colleges, have to pay tuition, which now amounts to $150. There is keen competition for these scholarships and the successful candidates are held rigidly to a very high standard of work. No honors conferred in the name of the university are more effective in promoting unusual excellence in scholarship.

The committee also suggests to the directors of the Alumni Association that further effort should be made to correct in the minds of our students the impression that the alumni as a body are concerned chiefly or exclusively with the athletic prestige of the university and that they reserve their approval for those students who have achieved success in athletics or in other extra-curricular activities. The action already taken by the alumni organization in initiating the inquiry to which this report is a response is itself evidence to the contrary and has already had its effect on undergraduate opinion. Nevertheless, it must be recognized that too many alumni lend support to the doctrine that it is ''college life,'' rather than university work, which counts the most. As Mr. Newman says, a generation of alumni has gone out more or less inoculated with the idea that efficiency gained through ''outside activities'' is the best thing to be had from college life. ''We are confronted,'' says the *Alumni News* (March 1, 1917), ''by an undergraduate state of mind which most of us have helped, in the last thirty years, to create.'' To the more mature alumni in particular, and to all those who are unable to worship what has been called the Idol of Incidental Issues, the university must look for a sustained effort to revive the older and sounder traditions of Cornell, as a place where men's work counts for more than boy's play.

It must also be admitted that the boys' play is in many respects salutary and necessary. Professor Willcox points out that the lack of opportunities for social and competitive intellectual effort has led to the creation of student organizations in which the social desires for coöperation or team-work and competition or emulation can find expression. Among those men who win the C in athletics or who secure other prizes of undergraduate life there is a good proportion of high-grade students. They are often men of exceptional ability and admirable character, and the chief pity is that their desire and determination to excel have been diverted so largely into less important activities, that they have consequently lost much of the intellectual development which they were naturally qualified to attain, and that their prominence and popularity lead to a great depreciation of intellectual values. In general, we believe that the attitude of the undergraduates toward these things, if they are left to themselves, tends to become sane and sensible; but unfortunately the financial problems involved in the maintenance of a high standard of athletic achievement make it necessary to exaggerate its significance and particularly to resort to an extensive and intensive campaign of publicity which helps to drown out the claims of other and higher interests. If, by means of an athletic endowment, season tickets and gate receipts could be dispensed with, we believe that the evils of athletics would be largely if not entirely obviated; and there is no problem which deserves the attention of the alumni organization or of individual alumni more urgently than this.

Our athletes are, for the most part, modest and sensible fellows; but it would not be their fault if their heads were turned by the attention and the publicity which they sometimes receive. When, moreover, an influential group of Cornell alumni invites the representative schoolboys of its city and representatives of the alumni organizations of sister universities to turn out in honor of the captain of a champion football team, it is not surprising if some of those boys come to college with the idea that athletic distinction is the crown of an academic career. When two thousand Yale alumni, led by Mr. Taft, Mr. Depew, and Mr. Vance McCormick, assemble in honor of Yale's athletic heroes for the formation of a Varsity Club, to include all wearers of the Y, a Yale freshman may be pardoned for regarding that honor as more attractive than membership in Phi Beta Kappa. Within proper limitations all this has a natural justification, but it has gone too far. At their banquet this year the Cornell freshmen were told that if a Cornell man took more pride in his C than in his diploma, it was because he might get his degree by bootlicking or bluffing, but he could not get a C that way. If there is any basis for this remark it is the fault of the faculty, but we believe the assumption to be unwarranted. It is true that candidates for athletic teams are advised to ''get their lessons first,'' but no student will go very far who thinks that he is here to ''get his lessons'' rather than to take part in an age-long, organized campaign to advance the frontiers of science.

Again the committee would emphasize the importance of the influence exerted by individual alumni upon those undergraduates with whom they are acquainted, and again it suggests that an organized effort might be made to develop such individual influence.

One form of activity on the part of individual alumni or of alumni clubs which might well be promoted by the general alumni organization would be an effort to enlist for Cornell those boys and girls who at school have shown intellectual qualities which appear to warrant the expectation that they will make exceptionally good use of their opportunities at the university and that they will ultimately attain to positions of leadership in life. If it be true that there is a demonstrable and positive relationship between the valuation of ability at school and at the university, if it be true that the same relation exists between the promise given by undergraduates and their performance in professional schools, if it be true that the success of the undergraduate in his studies is the safest single measure of the success he is likely to achieve in later life, then the university will be heavily indebted to any alumnus who guides a gifted youth to his alma mater. Cornell does not need more men of merely athletic prowess or of merely social distinction but it needs all the time more men and women of ability, not only for the honor that they may bring the university in later life, but chiefly for the services that they may render while they are here in securing recognition for scholarship, in quickening the whole body of undergraduates, in taking an active part in the coöperative advancement of knowledge. It must be recognized that the man, who, as an undergraduate, really ''does the most for the university'' is the man who helps it to do its work well.

Other and abundant opportunities for personal service are within the reach of all those alumni who are members of fraternities. A special responsibility rests upon the shoulders of fraternity alumni resident in Ithaca, but of the others there are many who come back frequently, and all are in a position to exert a continual and an intimate influence upon the corporate life of their younger brothers. So far as our experience and observation go, the undergraduate chapters appear to be reasonably willing to listen to the advice of their alumni. We must not demand too much; we must not expect gray heads to grow upon young shoulders; but we have a right to expect that every chapter here shall regard itself not as a boarding club but as a permanent social group, with traditions, with an outlook into the future, with a sense of its responsibilities as an integral part of an intellectual community. In every fraternity there are men who are endeavoring to live up to this high calling. Let the alumni in each fraternity back up such men; let them show their approval of a delegation which attains a good scholastic average, whether measured by marks or otherwise; let them encourage the active chapter to select among its initiates some men who give promise of the highest intellectual achievement and to bestow its approval upon those who fulfill such promise; let them encourage a man of ability and ambition to regard intellectual activity or possibly an academic career as an opportunity to serve his university and his country well. In too many fraternities freshmen and sophomores are virtually compelled to enter competitions of whose value they are not qualified to judge. In all fraternities there is a tendency to repress individuality, which can only be corrected by conscious and serious effort. There is a tendency to take more satisfaction in transient popularity and in ''the lightly proffered laurel of the campus'' than in the hard-won and less obvious rewards of moral and intellectual endeavor.

In one Cornell chapter of a national fraternity there is a scholarship key to be worn by that member who attains the highest scholastic standing. In another there are two annual prizes, one for that member whose marks are the highest, the other, of equal value, for the man who makes the most decided improvement over his record during the preceding term. Mr. Hoy tells us that he has just started two similar prizes in the fraternity of which he is a member and that he has had no trouble in getting more money from the chapter alumni than he needed for the purpose. Mr. Sailor suggests that a group of fraternity alumni might put up a scholarship trophy, to be held for a year by the chapter whose academic standing is the highest on the hill, and to become the permanent property of the chapter which wins it three or possibly five times. He also suggests that the alumni organization of any national fraternity might offer a prize to that chapter which, in any year, shows the most marked improvement in academic standing, as compared with other chapters of the same fraternity within a certain district. The committee is informed that the alumni of one Cornell chapter of a national fraternity have decided to provide a fund for two graduate fellowships to be filled each year by the best candidates from the fraternity at large, who will be expected to live in the house. We are also informed that many fraternities here have abandoned the literary exercises which, as is commonly believed, were once generally characteristic of chapter meetings. We suggest that fraternity alumni might promote a reconsideration of the value of such literary work and that, wherever it is resumed, annual prizes, possibly in the form of books, might be awarded to those members who have shown in such work the greatest originality or the greatest improvement. We also suggest that fraternity alumni should do their part to keep the chapter libraries well supplied with new and useful books, especially books relating to university life and education.

The committee suggests that the directors of the Alumni Association consider the advisability of holding an inter-fraternity alumni conference for the consideration of such questions as have just been indicated and of others that also require attention. It further suggests that at the general alumni reunion some such consideration be given to the serious problems by which the university is confronted as was contemplated for the first convention of Cornell Alumni. It ventures to hope that this report may suggest some topics the discussion of which by the alumni would throw further light on the problem which they have asked the faculty to consider.

Finally, we call attention to the concluding portion of a letter recently received by a member of the faculty, transmitted by him to this committee, and appended to this report. The letter was written by an alumnus of the class of 1915 and is published with his permission. He looks back upon his undergraduate days as a time of disappointment and disillusionment, due to the contrast between what he had expected and what he actually found at the university. He came up with a keen desire to know; but somehow no one seemed to care. He expected four years of intellectual companionship; but he found none. While some other men of similar interests and aims may have been more fortunate in finding congenial associations, we know that his experience was not unique, we believe that there are many who could make his words their own. They are less unfortunate, after all, than those who are not aware of what they are missing. It was for men of serious purpose that Cornell was founded; and we hope and believe that the time will come when they will again find here an intellectual atmosphere as keen and as congenial as in the early days of the university. In the course of time it has become a vastly larger, a less homogeneous, a more sophisticated community; we could not, if we would, revert to all its former simplicity; but, under new and complex conditions, we may, if we will, maintain what is best in our tradition. Under the new discipline of war, as the president of the university has predicted, the whole country may become more sober-minded. Among the students who will come to us in the near future there may be many more who have learned to think seriously and to take their work seriously. We must make sure that such men are not disheartened but sustained by the spirit of the university. We must try to surround them with a social atmosphere favorable to the development of their gifts. We must make our appeal to the best aspirations of every one whom we admit to our fellowship. However large the number of our students may be, we must try to deal with them as individuals in a free community; for a university, as Cardinal Newman said, is an alma mater, knowing her children one by one, not a foundry, or a mint, or a treadmill. The war, which for the time being enforces a reduction in the size of the university and the suspension of many of its activities, may give us time, as it surely imposes upon us an obligation, to take thought and to prepare for the conditions which will confront us at its close. That there is work here for the alumni as well as for the faculty this report has attempted to indicate.

Respectfully submitted,

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June 1, 1917.

REINFORCED CONCRETE THEORY WITHOUT THE AID OF FORMULAS.

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CONCLUSION.

The design in matters pertaining to tensile and compressive stresses is within the limits of the specifications, and we are ready to take up the consideration of bond and shearing stresses.

Figures 5*b* and 5*c* represent respectively the variations of shear and bending moment. The two diagrams present several interesting features.

1. The horizontal unit of measure is one inch in both diagrams. The vertical unit of measure in the shear diagram is one pound, while the vertical unit of measure in the moment diagram is one inch-pound.

2. Since the beam carries a load of 58 pounds per inch, the shear line has a slope of 58 pounds to the inch.

3. The slope of the tangent to the moment curve at any ordinate shows the change-per-inch, or rate of change of the bending moment at that section of the beam, and equals the length of the corresponding ordinate in the shear diagram. Hence the rate of change-per-inch of the bending moment at any ordinate equals the shear at that ordinate. Thus at ordinate *A* the shear is 3,480 lb. and equals the rate of change (3,480 in.-lb. per in.) of the bending moment at the end of the beam. The moment curve is ''steepest'' and the rate of change of bending moment is greatest at the section of greatest shear. The bending moment increases less rapidly as the shear decreases and, ceasing to increase, becomes a maximum at *F*, where the shear ordinate is zero. The bending moment

(whether positive or negative) always reaches *a* maximum (not necessarily *the* maximum) wherever the shear curve passes through zero.

4. The difference in the lengths of any two ordinates in the moment diagram equals the area of the shear diagram between them. Thus in the moment diagram, the difference in lengths of the D and E ordinates is 1,769 in.-lb., which equals

$$\frac{1{,}798 + 1{,}740}{2} \text{ lb.} \times 1 \text{ in.},$$

the area in the shear diagram. The moment at the A ordinate is zero, hence

$$\frac{3{,}480 + 1{,}798}{2} \text{ lb.} \times 29 \text{ in.} = 76{,}531 \text{ in.-lb.},$$

the length of the D ordinate of the moment diagram. Finally the moment at F is

$$\frac{3{,}480 \text{ lb.} \times 60 \text{ in.}}{2} = 104{,}400 \text{ in.-lb.}$$

The amount of tension (T) or compression (C) at any section of this beam equals the bending moment divided by the effective depth (9.94 in.) and therefore varies as the bending moment. The diagram of Fig. 5*e* may be called a "tension-compression diagram" since each ordinate equals the length of the corresponding ordinate in the moment diagram divided by 9.94 inches. The vertical unit of measure in the moment diagram is one inch-pound. Each ordinate in the T or C diagram represents $\frac{\text{inch-pounds}}{9.94 \text{ inches}}$; hence the unit of measure is one pound.

The length of any ordinate in the diagram of Fig. 5*d* may be obtained by dividing the length of the corresponding ordinate of the shear diagram by 9.94 inches. Hence each ordinate in the diagram of Fig. 5*d* represents $\frac{\text{pounds}}{\text{inches}}$ or pounds-per-linear-inch.

The explanation of the fact that the rods at one section may have a tension, greater or less than the tension at another section, is the adhesive force or bond stress between the rods and the concrete.

Now the same relations must necessarily exist between Figs. 5*d* and 5*e* that hold between Figs. 5*b* and 5*c*. The slope of the tangent to the *T* or *C* curve at any ordinate shows the change-per-inch (rate of change) of the tension in the rods (or the compression in the concrete) for that section of the beam. This slope equals the length of the corresponding ordinate in Fig. 5*d*. Since any ordinate in Fig. 5*d* measures the rate of change-per-inch of the tension in the rods, it must measure also the intensity of the bond stress per linear inch. Therefore Fig. 5*d* may be called "the bond-stress-per-linear-inch diagram."

Consider the two sections of the beam at ordinates *D* and *E*. The tension in the rods is (Fig. 5*e*) 7,877.3 lb. at section *E*, and 7,699.3 lb. at section *D*, a difference of 178 lb. It is evident that the bond between the concrete and steel must account for this difference in tension.

The diagram in Fig. 5*d* shows that the bond stress per linear inch varies uniformly from 181 lb. at *D* to 175 lb. at *E* in a length of one inch. The average bond stress is

$$\frac{181+175}{2}=178 \text{ lb. per linear inch}$$

for this inch-length of beam.

The surface area of the three $\frac{1}{2}$-inch square bars in a length of one inch is 6 square inches. Hence the surface area per linear inch is $\frac{6 \text{ in.}^2}{1 \text{ in.}}=6$ inches. The bond stress per square inch of surface area or the bond unit-stress is obtained by dividing the bond stress per linear inch by the surface area of the three rods per linear inch (Fig. 5*f*). Hence the bond unit-stress at *E* is

$$\frac{175\,\frac{\text{lb.}}{\text{in.}}}{6\text{ in.}} = 29.2\,\frac{\text{lb.}}{\text{in.}^2}\text{ or }29.2\text{ lb. per sq. in.;}$$

at *D* it is 30.2 lb. per sq. in.

The greatest bond unit-stress is required at *A* and is

$$\frac{350.1\text{ lb. per lin. in.}}{6\text{ sq. in. per lin. in.}} = 58.4\text{ lb. per sq. in.}$$

The specifications allow 80 lb. per sq. in. The diagram in Fig. 5*f* shows the variation of bond unit-stress.

Shear.—By referring to a portion of the beam between any two vertical sections, as for example *D* and *E* (Fig. 5*a*), we note a shearing force on any horizontal section. The shear on the section *SS*, located at any* depth between the neutral plane and the rods, equals the difference in tension or the bond stress. Hence Fig. 5*d*, which represents the intensity of bond stress per linear inch, may represent also the intensity of horizontal shearing stress per linear inch, *on horizontal sections between the neutral plane and the rods.*

The horizontal shearing stress per square inch equals the horizontal shear per linear inch divided by 7 inches, the breadth of the beam. The diagram in Fig. 5*h* shows the variation of the horizontal shearing unit-stresses below the neutral plane for different vertical sections of the beam.

The horizontal shearing unit-stress is constant for all points in a given vertical section between the neutral plane and the rods, and equals

$$\frac{\text{shear at the section}}{\text{effective depth} \times \text{breadth of the beam}}.$$

The greatest horizontal shearing unit-stress is at *A* and is

$$\frac{3{,}480\text{ lb.}}{9.94\text{ in.} \times 7\text{ in.}} = 50\text{ lb. per sq. in.}$$

---

* This statement is based on the assumption that the concrete resists no horizontal tension due to bending moment.

Let us continue our discussion by referring to Fig. 6*a*, which represents the inch-length of beam adjacent to left support. The horizontal shear on a section just above the rods is 347.2 lb. As no tension is considered as acting in the concrete, there will be no change in this shear on any horizontal section below the neutral plane. Above the neutral plane the shear will decrease until it equals zero at the top surface. The decrease at any horizontal section is determined by the amount of compression represented by the triangular area below it. At section *P*, one fourth of the distance above the neutral plane, the shear is 347.2 $(1-\frac{1}{16})$ lb.; at *Q* the shear is 347.2 $(1-\frac{4}{16})$ lb.; at *R* it equals 347.2 $(1-\frac{9}{16})$ lb. The shear decreases as the square of the distance above the neutral plane. This decrease in shear, resulting from the integration of a triangle, is a parabolic variation, as represented in Fig. 6*b*. A similar relation exists between the triangular shear diagram and the parabolic moment diagram, Figs. 5*b* and 5*c*.

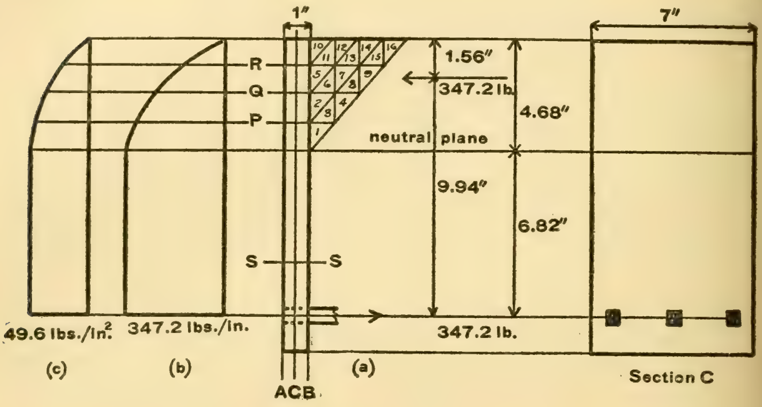

FIG. 6.

The horizontal shear on a section *SS* was found to be 347.2 pounds. The intensity of the horizontal shearing stress per linear inch is not constant across the section *SS* from *A* to *B*, but varies *uniformly* in accordance with the diagram in Fig.

5*d*. Hence Fig. 6*b* may be taken as the intensity of the horizontal shearing stress per linear inch at the section C midway between A and B. Fig. 6*c* is constructed by dividing the shear intensities of Fig. 6*b* by 7 inches, the breadth of the beam. Consequently Fig. 6*c* represents the horizontal shearing unit-stresses at the section C.

In accordance with a law of the mechanics of beams which states that the horizontal and vertical shearing unit-stresses at any point in a beam are equal, the diagram in Fig. 6*c* may represent also the vertical shearing unit-stresses on the section C. Let us see if the summation of the vertical shearing unit-stresses on the section C equals $3{,}480 - \frac{58}{2} = 3{,}451$ lb., the total external shear on the section. The area of the cross-section C below the neutral plane is 6.82 in. × 7 in., on which the vertical shearing unit-stress is constant and equals 49.6 lb. per sq. in. Above the neutral plane the vertical shearing unit-stresses have a parabolic variation from 49.6 lb. per sq. in. at the neutral plane to zero at the top surface; hence the parabolic area above the neutral plane (Fig. 6*c*) may be taken as the sum of the vertical shearing stresses on a vertical strip one inch wide of the cross-section above the neutral plane. The summation of the vertical shearing stresses on the section C may be made as follows:

$$49.6\,\frac{\text{lb.}}{\text{in.}^2} \times 6.82 \text{ in.} \times 7 \text{ in.} = 2{,}368 \text{ lb.}$$

$$\tfrac{2}{3}\left(49.6\,\frac{\text{lb.}}{\text{in.}^2} \times 4.68 \text{ in.}\right) 7 \text{ in.} = 1{,}083 \text{ ``}$$

$$\text{Total vertical shear at section } C = \overline{3{,}451} \text{ ``}$$

Our purpose is to parallel the generalities of the formula method and not to attempt a discussion of any particular theory. The conventional method for the design of stirrups will be followed as outlined in the text-book.

The maximum shearing unit-stress is 50 lb. per sq. in. (Fig. 5*h*) which is greater than 40 and less than 120 lb. per sq. in. Hence the cross-section has sufficient area, but web reinforcing is necessary for that portion of the beam where the shearing unit-stresses exceed 40 lb. per sq. in. The shearing unit-stresses increase uniformly from zero at the middle of the beam to 50 lb. per sq. in. at the end, hence $\frac{40}{50} \times 60$ in. $=48$ inches $=$ distance from center of beam to the section where web reinforcement is necessary. Reinforcing is required along the 12 inches of the beam adjacent to the supports. U-shaped vertical stirrups will be used.

There should be sufficient surface on the vertical length of the stirrup below the neutral plane to develop a bond stress equal to the tension in the stirrup. Since the surface area varies with the diameter of the stirrup, while the cross-sectional area varies as the *square* of the diameter, it is evident that for a given beam there is an upper limit to the size of stirrup which may be used economically. Let us investigate a $\frac{3}{8}$-in. round stirrup, and assume that the lower seven inches of its vertical length are available for bond surface. The bond surface on one leg is

$$\tfrac{3}{8} \text{ in.} \times 3.1416 \times 7 \text{ in.} = 8.2 \text{ sq. in.}$$

At 80 lb. per sq. in., the bond stress which may be developed on the surface of one leg is

$$8.2 \text{ sq. in.} \times 80 \frac{\text{lb.}}{\text{in.}^2} = 656 \text{ lb.}$$

The cross-sectional area of a $\frac{3}{8}$-in. round bar is .1104 sq. in.; hence the tension which may be developed in one leg is

$$16{,}000 \frac{\text{lb.}}{\text{in.}^2} \times .1104 \text{ in.}^2 = 1{,}770 \text{ lb.}$$

A smaller diameter should be chosen; try a $\frac{1}{4}$-in. round bar.

$$\tfrac{1}{4} \times 3.1416 \times 7 \times 80 = 440 \text{ pounds — bond stress}$$

and

$$.0491 \times 16{,}000 = 785 \text{ pounds — tensile stress.}$$

While bond still seems to limit the amount of stress which the stirrup may be expected to carry, we will accept Hool's statement that the rods may be considered secure against slipping if bent at their upper ends. One stirrup, therefore, is assumed to develop $2 \times 785 = 1{,}570$ lb.

The reinforcing is supposed to provide for two thirds of the vertical component of diagonal tension, the remaining one third being carried by the concrete. Since the diagonal tension is considered as acting at an angle of 45 degrees from the horizontal, its vertical and horizontal components are equal, and the spacing is usually measured by two-thirds of the horizontal shear per linear inch.

At the end of the beam the horizontal shear per linear inch is 350.1 lb. (Fig. 5*d*). Hence at the ends of the beam the theoretical spacing of the stirrups is

$$\frac{1{,}570}{2/3 \times 350.1} = 6.7 \text{ inches.}$$

. . . .

The discussion of a new topic should be introduced at the "psychological moment." The disastrous result which too frequently follows a non-conformity to this rule may be illustrated by a reference to the writer's personal experience in discussing the impact ratio $\frac{300}{(l+300)}$, as given by the American Railway Engineering Specifications. The class had become reasonably proficient in the computations of live-load stresses, and the impact ratio was brought up in connection with a bridge 300 feet in length. The reader will understand how later developments convinced the writer that any other span length would have been more appropriate for the first application.

The writer believes that the question of average vertical shearing unit-stress should not be mentioned until the end of the treatment of rectangular beams and slabs, when the evaluation of the maximum shearing unit-stresses of 40 and 120 lb. per sq. inch in terms of their averages (35) and (105) will be less confusing.

T-Beams.—The illustrative problem on page 153 of the text-book is chosen as a fair example for comparing the amount of work required by the two methods—formula and numerical.

Design a T-Beam with span of 40 ft. Assume dead load $=1{,}400$ lb. per foot. Live load $=3{,}000$ lb. per foot. The beam is to be simply supported at the ends, and the flange does not form a part of a floor system already determined. Use working stresses recommended by the Joint Committee.

The total bending moment,

$$M=10{,}560{,}000 \text{ in.-lb.}$$

The maximum shear,

$$V=88{,}000 \text{ lb.}$$

The required net web area,

$$b'd=\frac{88{,}000}{105}=838 \text{ sq. in.}$$

To give ample space for the steel and still obtain satisfactory proportions for the cross-section, we shall select $b'=18$ in. and $d=47$ in. for a preliminary design. A thickness of flange of 12 in. will be tried.

FORMULA METHOD.

$$\frac{t}{d}=\frac{12}{47}=0.256,$$

$$k=\frac{1}{1+\dfrac{f_s}{nf_c}},$$

$$k=\frac{1}{1+\dfrac{16{,}000}{15\times 650}}=\frac{9{,}750}{25{,}750}=0.378,$$

$$kd=0.378\times 47=17.8 \text{ in.},$$

$$z=\frac{3kd-2t}{2kd-t}\times\frac{t}{3},$$

$$z = \frac{(3 \times 17.8) - (2 \times 12)}{(2 \times 17.8) - 12} \times \frac{12}{3} = \frac{53.4 - 24}{35.6 - 12} \times 4$$

$$= \frac{29.4}{23.6} \times 4 = 5 \text{ in.},$$

$$jd = d - z = 47 - 5 = 42 \text{ in.},$$

$$M_s = f_s a_s jd, \quad a_s = \frac{M_s}{f_s jd},$$

$$a_s = \frac{10{,}560{,}000}{16{,}000 \times 42} = 15.7 \text{ sq. in.},$$

$$M_c = f_c\left(1 - \frac{t}{2kd}\right) bt.jd,$$

$$b = \frac{M_c}{f_c\left(1 - \frac{t}{2kd}\right) t.jd},$$

$$b = \frac{10{,}560{,}000}{650\left(1 - \frac{12}{2 \times 17.8}\right) 12 \times 42}$$

$$= \frac{10{,}560{,}000 \times 35.6}{650 \times 23.6 \times 12 \times 42} = 48 \text{ in.}$$

We shall use

5 $1\frac{3}{8}$-in. round rods	@ 1.485 =	7.4	sq. in.
7 $1\frac{1}{4}$-in. " "	@ 1.227 =	8.6	" "
		16.0	" "

The $1\frac{3}{8}$-in. rods will constitute the bottom row. Five $1\frac{1}{4}$-in. rods will be placed in the middle row with the two remaining rods above them. The three rows are spaced two inches apart.

The center of gravity of the group of rods is

$$\frac{(5 \times 1.23 \times 2) + (2 \times 1.23 \times 4)}{16} = 1.4 \text{ in. above the center line of the lowest row.}$$

The bond for one $1\frac{3}{8}$-in. round rod is

$$u = \frac{V}{\Sigma ojd} = \frac{88,000}{4.3197 \times 42} = 485 \text{ lb. per sq. in.}$$

The number of rods which must extend to the end of the beam is

$$\frac{485}{1.5 \times 80} = 4.$$

Web reinforcement is unnecessary at a distance from support equal to

$$x_1 = \frac{l}{2} - \frac{v'b'jd^*}{w},$$

$$x_1 = \frac{40}{2} - \frac{40 \times 18 \times 42}{4,400} = 20 - 6.9 = 13.1 \text{ ft.},$$

$$BC = \frac{2}{3}\frac{Vb}{bjd} = \frac{2}{3}\frac{88,000}{42} = 1,395 \text{ lb. (Fig. 75 in text-book)},$$

$$r = 0.7AD = 0.7 \times 13.1 \times 12 = 110 \text{ inches.}$$

Hence, total stress to be taken by the rods is

$$\frac{BC}{2}r = \frac{1,395}{2} \times 110 = 76,700 \text{ lb.}$$

Six rods may be bent up, two at a time, in the following order:

$$x_2 = \text{or} < \frac{l}{2}\left[1 - \sqrt{\frac{m_2}{m}}\right],$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{2 \times 1.227}{16}}\right] = 12.18 \text{ ft.},$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{4 \times 1.227}{16}}\right] = 8.94 \text{ ft.},$$

$$x_2 = \text{or} < \frac{40}{2}\left[1 - \sqrt{\frac{6 \times 1.227}{16}}\right] = 6.44 \text{ ft.}$$

---

[*] This formula is found on page 95 of the text-book, except that b' is substituted for b. How many instructors find that the student makes this correction?

Numerical Method.

Refer to sketch in Fig. 7.

$$k : 1 - k :: 650 : \frac{16{,}000}{15},$$

$$1{,}067k = 650 - 650k,$$

$$k = \frac{650}{1{,}717} = 0.378,$$

$$47k = 0.378 \times 47 = 17.8 \text{ in.},$$

$$f : 650 :: 5.8 : 17.8,$$

$$f = 212 \text{ lb. per sq. in.}$$

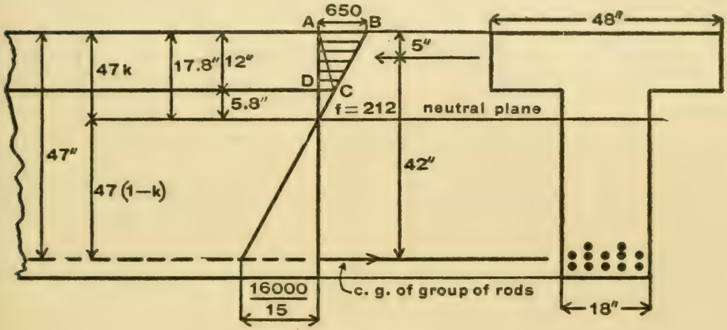

FIG. 7.

Moment of area *ABCD* about *AB*.

$212 \times 6 \times 8 = \quad 10{,}180$

$650 \times 6 \times 4 = \quad 15{,}600$

$862 \times 6 = 5{,}172 \overline{)\,25{,}780}$

5 in. from top surface to resultant compression.

$$\begin{array}{r} 47 \\ \underline{5} \\ 42 \end{array}$$

Effective depth is 42 in.

$42 \overline{)\,10{,}560{,}000} =$ moment

$16{,}000 \overline{)\quad 251{,}400} =$ tension or compression.

15.7 sq. in. of steel required.

5,172)251,400 = compression
48 in. = breadth of flange.

The center of gravity of the group of rods is

$5 \times 1.23 \times 2 = 12.3$[*]

$2 \times 1.23 \times 4 = 9.8$
16)22.1
1.4 in. above the center line of the lowest row.

42)88,000 = shear at end of beam.
120)2,100 lb. per lin. in., bond stress and maximum horizontal shearing stress at end of beam.

4.3197)17.5 sq. in. per lin. in., bond surface required at end of beam.

4 rods must extend to end of beam.

18)2,100 lb. per lin. in., maximum horizontal shearing stress at end of beam.

117 lb. per sq. in., horizontal shearing unit-stress at end of beam.

$$\frac{40}{117} \times 20 \text{ ft.} = \begin{array}{r} 20 \\ \underline{6.9} \end{array}$$

at 13.1 feet from end of beam, the shearing stress has decreased to 40 lb. per sq. in.

Six rods *may* be bent up two at a time in the following order (Fig. 8):

---

[*] The average student entering upon his professional studies in the junior year frequently brings with him a few academic ideas which do not find favor in the eyes of the engineering instructor. An illustration is found in a comparison of the academic and professional arrangement of the computations for finding the center of gravity of the group of rods as set forth in the formula and numerical methods respectively. To the reader who has had a professional training as a draughtsman, checker or designer, comments are unnecessary.

$$\left(\frac{y_1}{2}\right)^2 : \left(\frac{40}{2}\right)^2 :: 2.454 \text{ sq. in.} : 16 \text{ sq. in.}$$

$$y_1 = 40\sqrt{\frac{2.454}{16}} = 15.64 \text{ ft.},$$

$$y_2 = 40\sqrt{\frac{4.908}{16}} = 22.12 \text{ ft.},$$

$$y_3 = 40\sqrt{\frac{7.362}{16}} = 27.12 \text{ ft.}$$

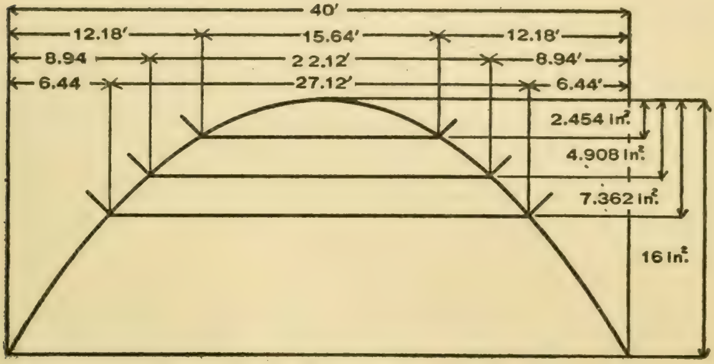

FIG. 8.

The writer believes that the graphical solution for locating the points at which the six rods *should* be bent up, may be somewhat simplified. The diagram in Fig. 9 corresponds in

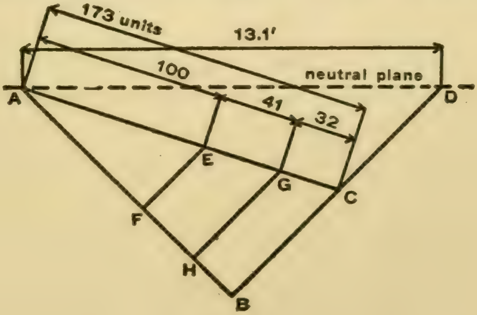

FIG. 9.

part to the author's diagram in Fig. 75, page 155. The areas of similar polygons are proportional to the squares of their homologous sides. If the triangle *ACB* is divided into three equal areas by the lines *EF* and *GH*, drawn parallel to *BC*, then

$$\text{area} \triangle AEF : \text{area} \triangle AGH : \text{area} \triangle ACB$$

$$:: \overline{AE}^2 : \overline{AG}^2 : \overline{AC}^2 :: \tfrac{1}{3} : \tfrac{2}{3} : \tfrac{3}{3},$$

$$AE : AG : AC :: \sqrt{\tfrac{1}{3}} : \sqrt{\tfrac{2}{3}} : \sqrt{\tfrac{3}{3}} :: 100 : 141 : 173.$$

or

$$AE : AG : AC :: 100 : 141 : 173.$$

The points *E* and *G* are easily located if the point *C* is chosen on the line *BD* so that *AC* will represent 173 units of measure to some convenient scale. If it were desired to divide the triangle into four, five or six equal areas, the point *C* should be chosen so that *AC* would scale 200, 224 or 245 units respectively.

. . . .

Introduction and climax, plot and dialogue are vital to the technic of a 50-minute recitation no less than to the structure of a short story. A recitation can be as interesting as a series of hairbreadth escapes or as prosaic as the "begats" of the Pentateuch. The instructor who stands in front of his desk and begins the first recitation of the course by asking John Smith how many barrels he thinks there would be in a mixture of one barrel of footballs, two of baseballs, and three of golf balls, has more than an even chance of enlisting sympathy and interest. The instructor who puts his knees under the mahogany, opens the book to page 7, and asks Smith to name the laws governing the theory of proportions—has missed his calling.

The average student experiences nothing very exciting in the derivation of a formula. It is true, perhaps, that the "plot thickens" with the procedure, but not in a manner which tends to stimulate his interest. Having studied a lesson, let us say on bond stress, he has been able to derive the formula

$$u = \frac{V}{\Sigma ojd}$$

upon the blackboard to the entire satisfaction of his instructor, made a grade of 100 per cent and acquired some information, and that is all. The process is a Simon-pure exercise in memory work, and measures up reasonably well with the standard recently set by the college professor who remarks, "The instructor who goes into the class-room has two functions to perform; first, to impart information, and second, to maintain discipline." Possibly one function necessitates the other. Professor Swain seems to have a different view of the matter. He says: "Education is an opportunity, nothing more. It will not guarantee success or happiness or contentment or riches. Everything depends upon what development is produced by it and what use is made of it."* Development, that is a large word. Evidently we as teachers are employed to develop something, somehow, and somewhere. The first question is then: What are we supposed to develop?

Locke in 1690 said: "That which every gentleman (that takes any care of his education) desires for his son, besides the estate he leaves him, is contained (I suppose) in these four things, virtue, wisdom, breeding and learning. . . . You will wonder, perhaps, that I (being a bookish man) put learning last, especially if I tell you I think it the least part."†

It cannot be said that Locke's theory has waxed old and is ready to die. The demands of the engineering profession as set forth in Dr. Mann's report of the Joint Committee on Engineering Education seem to be in accord with Locke's idea. The profession is on record as claiming that *character, integrity, responsibility, resourcefulness* and *initiative* are 24 per cent of the engineer's total equipment; that *judgment, common sense, scientific attitude* and *perspective* represent 19.5

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* "How to Study," by George F. Swain, McGraw-Hill Book Co.

† Essay: "Some Thoughts Concerning Education," § 134.

per cent; that *efficiency, thoroughness, accuracy* and *industry* represent 16.5 per cent; that *understanding of men* and *executive ability* represent 15 per cent; that *knowledge of fundamentals of engineering science* represents 15 per cent; and that *technique of practice and of business* represents 10 per cent. The words in this list seem to represent qualities, not things, nor facts, nor methods; and the development of these qualities should be our aim.

An attempt to re-classify each quality as a physical, mental or moral characteristic is an interesting exercise; but one fraught with perplexities and by no means conclusive, because of the very fact that physical, mental and moral attributes are not entities but functions each of the other. How can we doubt this fact when bad news affects our appetites and hunger tempts us to steal? Few of the characteristics, if any, are distinctly physical; while many are both mental and moral. Some of the qualities may be developed by study; others are the result of environment. Growth of character, like culture or refinement, comes from the influence of a personality as well as from the study of books. A non-technical elective may cause the student's intellectual horizon to recede and thereby give him breadth of view, but whether the student will gain culture and character is a question which concerns the personality of the instructor quite as much as the subject-matter of the course itself. Evidently we are to develop certain mental and moral qualities in the student, not only by precept but by example. How, then, shall we proceed?

The experiences of Smith and Jones are worthy of consideration. Smith decides to train for the two-mile run. He reports to the track coach, who gives him a two-mile ride over the course in a six-cylinder limousine, directs him to take a shower-bath and rub-down and to report at the same hour the next day. If this procedure is maintained indefinitely when will Smith become a bright and shining star in the athletic firmament?

Jones has other aspirations. He came to college "to get an education.'' He registers in a certain course and spends three hours weekly in the lecture-room taking copious notes, listening, sleeping or perhaps reciting *words* which he has learned from his notes or text-book. On the third Friday of each month, by an ''intensive review,'' he prepares for a written quiz on prescribed topics. At the end of the semester, by pumping all night, he sufficiently increases the pressure on his watered stock of knowledge to be able to flush a dozen pages during a formal and final examination which is conducted with great dignity; and gathers unto himself three semester-hours credit or the fractional part of a degree. But has Jones developed any of the specified qualities which will make for his success in engineering or in any other profession?

The experiences of the two men seem to differ materially in but one point. Smith's comedy is as imaginary as the value of the square root of minus one. The tragic experience of Jones is within the memory of many. Fresh air and cleanliness are essential for the athlete; but without strong lungs and agile limbs, he is beaten at the first barrier. Likewise memory exercise, although an important intellectual process, should not exclude imagination and reasoning. Which of these three plays the leading rôle in the drama of life is a question which is answered differently perhaps by the linguist, poet and scientist. It is a significant fact, however, that the majority of people who plead guilty to possessing a poor memory are much offended when accused of having little imagination or poor judgment.

We have in our midst physical training schools and manual training schools, fitting schools and finishing schools, reform schools and theological seminaries, technical schools and colleges, graduate schools and universities. But why do we never hear of *mental* training schools?

I believe that it was Professor Bird who said that he was not teaching chemistry, but rather employing chemistry as a means of teaching young men to think. Professor Swain remarks: ''The student is not an empty vessel to be pumped full of learning; he is a complex machine which education should help to run properly." It would be as difficult as interesting to ascertain how many educators have at one time or another subscribed to the statement: "We must make the student think," a mandate which frequently suggests the question: "How can you prevent his thinking?"

The student may interpret the instructor's request to think in several different ways. He will literally comply with the request if he memorize, imagine, reason or perform one of several other but minor intellectual functions. The intellectual development, however, varies with the form of exercise—a fact which the instructor should recognize and too often doesn't. There remains no doubt as to which intellectual function the student will *not* exercise when given a choice in the matter. Have you ever known students to memorize anything for the mere pleasure of it? On the contrary, when seen in pairs or groups and "on their own" they are more often than otherwise visualizing some future event in their lives or engaged in a heated argument. The subject of the argument may be trivial and the reasoning may not conform to the laws of logic, but that is not the point in question. They enjoy an argument: memory work is a task. How, then, does it happen that so many of them literally memorize their way through college? Perhaps it is because they are given little opportunity of doing anything else. Let us see.

I suppose that every college has its laboratory course which is caricatured by the student body as Physical-Training 13; or perhaps it is a lecture course known, *sub rosa,* as Morpheus 23. Such courses merit but a passing mention. But here is another course, let us say in the theory of reinforced concrete, conducted by a wide-awake, up-standing, thorough-going instructor. He assigns article 38 of our text for the next lesson, and tells the class that bond stress is a very important topic, which should be thoroughly mastered. How does Brown, who represents the average conscientious student, proceed with his lesson? As he reads the assignment, his attention is focused upon the derivation of the formula

$$u = \frac{V}{\Sigma ojd}.$$

Knowing the possibility of being called upon to derive the formula upon the blackboard, he follows the algebraic transformations very carefully to the end, memorizes the formula and says to himself, "I have got my lesson."

Brown has studied his lesson so thoroughly that on the following morning, as he walks to class, he can visualize and reproduce the lesson in his thoughts. But what does he *see*—the beam? I do not think so. The formula is his hero—and it finally becomes his master. He is gratified that he has a good text-book (in which I think we all concur) which makes everything clear and easy. During the recitation the formula is derived, explained, discussed and *ever thereafter used.*

Right here let us try an experiment. For two weeks or perhaps longer the class has been using the formula

$$k = \sqrt{2pn + (pn)^2} - pn,$$

which was derived in class *once* and has been used continually since that time. Suppose we ask the class point-blank to derive the formula for locating the neutral plane for reviewing the design of a rectangular beam. The results of such experiments are too frequently anything but gratifying.

Personally, I believe that Brown's experience is fairly representative. He has studied his lesson, exercised his memory, and gained some information. If anyone has exercised his imagination, it is the instructor, in thinking that Brown, in his study of article 38, has been exercising his reasoning faculties in the development of initiative, scientific attitude, and resourcefulness. The instructor who is frequently congratulated by his students upon his efficiency in "making things clear and easy" should at once take stock of his method and decide whether he is developing his students mentally, or simply feeding them information. The student is soon brought to the borderland of mental suicide if he is constantly given the opportunity of "learning a lesson" which contains a new principle, *before* that principle has been thoroughly discussed in the class. The student himself should be required to develop the principle and arrive at the proper conclusions in class; and this end can be accomplished if the instructor is a master of the science and art of quizzing.

We will try to illustrate our idea of a quiz upon a topic for which no lesson has been assigned.

Instructor. A ten-penny wire nail is driven vertically a half-inch into the ceiling timber beam. Would you risk your weight upon it?

Student. I would not.

I. How does the term "penny" with a numeral prefix happen to be used to designate the different sizes of nails?

S. I don't know.

I. Please report on it at the next recitation. Would you risk your weight if the nail were driven an inch and a half into the beam?

S. I think so.

I. What determines the force necessary to withdraw the nail?

S. The friction or adhesion between the nail and the surrounding wood.

I. In a discussion of reinforced concrete the adhesion between the concrete and steel is called bond stress.

In the freshman-sophomore tug-of-war there were twenty sophomores and a mule* on one end of the rope. At two points on the rope, between which three men are pulling, the tension is 400 and 700 pounds respectively. Discuss the situation.

S. The three men are pulling an average of one hundred pounds each.

I. How does each man deliver the 100 pounds to the rope?

S. By the friction between his hands and the rope.

I. The friction or bond stress between the concrete and the horizontal steel rods in a beam is a function of what?

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* The instructor who has no sense of humor is a misfit in the class-room.

S. It is a function of the tension in the rods.

I. The tension in the rod is a function of what?

S. It is a function of the bending moment.

I. If the bond stress is a function of the tension in the rods, and the tension in the rods is a function of the bending moment, what is your conclusion?

S. The bond stress is a function of the bending moment.

I. Where is the greatest bending moment in a simple beam, uniformly loaded?

S. At the middle of the span.

I. Where, then, is the greatest bond stress?

S. At the middle of the span.

I. At what point would the rods make the greatest effort to slip?

S. At the middle of the span.

The facial expressions of the class are an interesting study during the latter part of the quiz. An alert student who has been watching the instructor playing with the small deck of class cards which he has been bending into a cylindrical form, comes forward with the statement that the slip is greatest not at the middle of the span, but at the end, and ''the fight is on.''

The writer has never been able to agree with the opinion that the cause of a student's failure to pass in a course can always be traced to the instructor. He does agree, however, that it is usually the instructor's fault if a student is not interested in a course. The easiest and perhaps the best method of arousing interest is to provoke a verbal scrap among members of the class.

The instructor and the student whom he has been quizzing represent the ''government,'' and the burden of proof is put upon ''those of the opposition,'' who will eventually discover the fallacy in the argument; namely, that the bond stress is not a function of the tension per se, but of the *variation* in the tension, or variation in the bending moment, and the quiz continues.

I. Will you draw a picture illustrating your idea of the variation of bending moment?

The student sketches a simple beam uniformly loaded, draws the shear diagram, and directly below it the bending moment diagram.

I. What name is given to the curve in the bending moment diagram?

S. It is a parabola.*

I. What graphical relation exists between the two diagrams?

S. The ordinate or height at any point of the shear diagram measures the slope (of the tangent to the moment curve) or steepness of the moment curve at the corresponding point.

I. Where, then, is the greatest variation in height of the moment curve?

S. At the point of greatest shear.

I. Now make a summing up of the argument.

S. The bond stress is a function, *not* of the tension in the rods, but of the *variation* in the tension. The variation in tension is a function of the variation in the bending moment; and the variation of the bending moment is a function of the shear; therefore the bond stress is a function of the shear.

Of course, the answers as here given are not always forthcoming with the first attempt, frequently the instructor must attack the problem from a different angle; but always with the idea of getting upon common ground with the student by touching the latter's personal experience, thereby enabling the student to put side by side in his mind two ideas never before linked together in his thought. By such a method the student may develop mental power to cope with life's problems, the answers to which are not to be found between the covers of any text-book.

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* If time permits, this answer is given some attention. See ''The Structural Engineer's Parabola,'' *Journal of Western Society of Engineers,* April, 1917, p. 215.

UTILIZING INCENTIVE COMBINED WITH INTEREST IN TEACHING PRINCIPLES.

BY W. E. BULLOCK,

Assistant Secretary, American Society of Mechanical Engineers.

By those of us who were taught in the stoical school of fundamental principles, the modern movement toward vocational or occupational education is looked upon somewhat askance. We believe that attempts to teach vocations when commercial and industrial practice in those vocations advances so rapidly is not the ideal way from many points of view. We believe further, a two-years' try-out of a vocation in a classroom, though it may reveal the aptitude of the student, gives little indication of his ultimate propensities, since the experiment is a laboratory rather than an economic one. We believe, when all is said and done, very little is gained in departing from the stoicism of fundamental principles, upon which all practice and experience are based, and a knowledge of which opens up to the student not one, but a vast number of vocations.

On the other hand, we realize, with our vocational friends, that the stoical school of fundamental principles is not at all attractive to the average student in this industrial age. He has preformed a mind of his own which is realistic rather than fundamental, and which therefore sees little interest in studying the causes of things. With due respect to our vocational advocates, we suspect that this is one of the reasons for their being—the impatience of the student to learn application before principle, and the consequent impossibility of grinding the fundamental principles into his system so hard and so long that they become a part of his being.

Those of us whose business it is to impart knowledge should bear in mind that not the least of the numerous factors upon which the degree of assimilation of the knowledge we wish to impart depends, are interest and incentive. A student will assimilate nothing which does not interest him, and he will assimilate more readily when he sees some incentive to learn and an educational method which combines both interest and incentive therefore offers double advantages.

Of the two factors, interest and incentive, the former is not hard to excite; it is the one great factor which vocational systems depend on to give the clue to the student's aptitude—his vocation is revealed as the task in which his interest is a maximum. The latter is an exceedingly intangible factor, and apparently on account of this very few educators employ the incentive method to any extent.

The purpose of this contribution is to suggest a practical and logical manner of developing the combined factors of interest and incentive in educational systems, with a view to accomplishing the highly desirable result of indelibly impressing upon students the fundamental principles of science and of giving them a mental equipment which will accrue to their advantage in the vocations.

The method utilizes as the primary incentive (it may be sacrilegous to say so before a professional organization) the ultimate turning of the knowledge of the principles to financial account. This is the strongest possible incentive that could be devised. It is the incentive which every student creates within himself, his only reason for wanting to learn, and its universality should therefore assure its recognition as a legitimate educational factor.

The method consists in nothing more nor less than teaching, in definite curriculum, the science of inventing, *per se,* truly a science, but one which probably as little educational effort has been expended to teach as any science, and which certainly has never been included in any school course.

By "the science of inventing" is meant the science of the application of the laws of nature, the properties of bodies, of elements, or of substances to produce certain results or attain certain objects for the use and benefit of mankind. This is the science in which interest is universal and which, thanks to the patent systems in vogue in the various countries, incentive is of the strongest.

The fundamentals of the science of inventing itself are few —they can be set down in a paragraph. Every invention comprises four natural divisions or stages:

1. The principles or laws of nature, the natural phenomena, or the properties of substances or things employed in the invention.
2. The method of application of those principles—a process of manufacture.
3. The immediate result, the article which is manufactured, or the substance which is produced.
4. The ultimate result, that is, the object attained or the use to which 3 is put.

These fundamentals themselves are learned in a few minutes, but the applications of them may be extended and varied to embrace the thousands of useful inventions that have been made, and—here is the crux of the matter—the list of examples chosen for the study may be graduated and may be so extensive that all the fundamental ''principles or laws of nature, natural phenomena, properties of substances or things'' are included in them.

Progressive examples may be given from year to year, and the same fundamentals demonstrated again and again, and interest in the subject will never wane because incentive never decreases—the inventive faculty, one of the strongest educational motives, is being steadily developed. And, as already stated, fundamental scientific principles will become at the same time automatically absorbed.

What easier way to imbue a student's mind with the principles of gravitation and inertia than by exemplifying the invention of the pendulum, in which is involved (according to the fundamentals already enunciated)

(1) The principles of gravitation and inertia involved in the period of oscillation;
(2) The forms, mode of suspension and attachment;
(3) The complete article produced;
(4) The resultant property of the device in being capable of isochronous motion

or the invention of the explosive, involving

(1) The laws of ignition and combustion of certain elements;
(2) The process of mixing ingredients under safe conditions;
(3) The explosive produced;
(4) The force due to the sudden generation of gases at high temperature;

or the invention of the electric light, involving

(1) The laws of heating effects of the electric current;
(2) The choice of materials and the mode of combining and joining them;
(3) The lamp itself;
(4) The production of light by incandescence of part of the circuit in turning on the current.

The method, of course, is to apply similar analyses to the above in the cases of a multiplicity of inventions, and, later on, to supply examples given one or more fundamentals and required to find the remaining ones. Thus, reverting to the example of the pendulum, the student might be asked to devise other inventions for producing isochronous motion (balance wheel); or, in the example of a dye-stuff, to enunciate the principles involved, and to describe their mode of application in making the dye.

He should further still have it kept before him that new discoveries of fundamentals (2) and (3), that is, new processes or methods of production and new vendible articles are in all cases patentable.

In conclusion, it might be mentioned that this putting of the teaching of inventing on a positive basis could not fail to produce, besides the directly resulting benefit to the student described, an indirect benefit in the form of raising the art of inventing to a higher plane. This indirect result is no mean one when it is considered that upwards of a million and a quarter "inventions" have been patented in this country in three quarters of a century, and that less than ten thousand of these are of real value. Inventors, as a class, are notoriously weak in scientific principles, and as a result much of their work is discredited by scientific men. Thousands of inventions, apparently practical, are upon analysis found to be based on incorrect knowledge of the laws of nature, natural phenomena, properties of substances or things.

The Franklin Institute of the State of Pennsylvania, one department of which has since 1824 annually reported upon inventions with a view of making awards, has so far found but 1,700 inventions worth reporting upon, or an average of 18 a year, though the number of patents granted each year runs into the hundreds of thousands! The Institute is trustee of a number of funds for making awards for meritorious inventions, but has, since 1824, only been able to make such awards in 400 cases, or at the rate of just over four a year, while the interest on one of the funds—the John Scott Legacy Medal and Premium, has accumulated to several thousands of dollars!

THE GRAPHICAL SIGNIFICANCE OF SOME ALGEBRAIC OPERATIONS.

BY ROY KEGERREIS,

New York City.

The concepts of most of the things in science to which mathematics is applied come to us through a picturing of curves, networks and geometric constructions. These graphs simulate the correspondence between the various factors and influences of the phenomena. Preparatory mathematical training will have less of a gap between it and the applied studies of science and engineering if a connection between the real and the abstract is constantly emphasized. Such methods are entirely similar to the application of analogies in the explanation of physical phenomena.

It seems as though we are too prone to operate with algebraic expressions per se, rather than at the same time to contemplate the beauties of our operations by viewing the corresponding scenes which are enacted on the coördinate plane. This matter is exceedingly important, since a majority of the ''scientific steps'' which we consider noteworthy are nothing more than a translation of a graphical concept to a mathematical one or vice versa. It is well known, for instance, that Faraday had a thorough and correct conception of the fields in the phenomena of electricity and it was only after reading his work that Maxwell set it into mathematical notation.

The power of manipulative ability in mathematics is a very desirable thing, which is possessed by few persons. However, it is generally the case that the ''turning the crank'' process will run much smoother if the student has a physical conception of what is being done, even though it may not necessarily always be viewed.

The retention of the various theorems will almost surely be more permanent if some appropriate picture can be tagged on to each one for the student's mind's eye to visualize. The application of such a translation of algebra to certain theorems will be discussed with the view of emphasizing its utility in teaching a second course in algebra, especially to engineering students.

THEORY OF EQUATIONS.

Quadratic Equations.

All algebras consider the three cases of the solution of the quadratic equation.

I. Real and unequal roots.
II. Real and equal roots.
III. Imaginary roots.

$$y = x^2 - 5x + 6 \tag{1}$$

is an example of the first case. The roots are 2 and 3 and the equation may be written

$$y = (x-2)(x-3) \tag{2}$$

by definition or factoring. This may be expressed by

$$y = (y_1)(y_2), \tag{3}$$

where

$$y_1 = x - 2, \tag{4}$$

and

$$y_2 = x - 3. \tag{5}$$

The graphs of equations (4) and (5) are the parallel straight lines of Fig. 1. Equation (3) tells us that the ordinates of

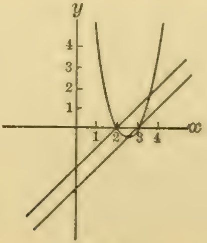

FIG. 1.

these two straight lines are to be multiplied together for each value of x. The curve which possesses these "product" ordinates is the graph of equation (1).

A parabola has been evolved from two straight lines, a thing which has a counterpart in calculus where it is shown that a parabola results if ordinates are made proportional to the integral of the right-angle triangular area between two intersecting lines. This is the case of real and equal roots (Fig. 2).

The above construction with the root factors shows the impossibility of having real roots in the third case. That is, it is impossible to plot two lines so that the product of their respective ordinates will produce the curve of Fig. 3.

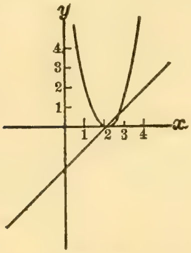

FIG. 2.

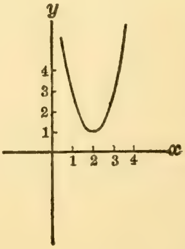

FIG. 3.

Higher Degree Equations.

A similar treatment of higher degree equations is also possible.

$$y = x^3 - 6x^2 + 11x - 6 \tag{6}$$

is a typical equation of this kind and may be written in the form

$$y = (x-1)(x-2)(x-3). \tag{7}$$

It is seen that there are three straight lines involved (Fig. 4). The products of their respective ordinates give the ordinates of the curve as shown.

It might be said that the graph of an equation, with all its roots real, consists of the "product" of as many straight lines of unit slope as there are roots. The intercept of the line with the x axis is determined by the sign and value of the corresponding root.

An entirely different graphical treatment for finding the roots of a quadratic or cubic equation is described in some text-books. It consists of separating the equation in two parts (parabola and straight line) which are subtracted from each other. The abscissæ of the points of their intersection are the roots of the equation.

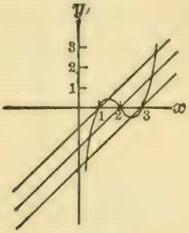

FIG. 4.

Descartes's Rule of Signs.

"An equation $f(x)=0$ cannot have more real positive roots than there are variations in sign of $f(x)$ nor more real negative roots than there are variations in sign of $f(-x)$."

The rule is universally demonstrated on a purely analytic basis and the philosopher-mathematician who formulated it very probably did so in this manner. The graphical workings of the rule are brought out if the equation is considered as a collections of terms.

Take the equation

$$y=ax^3+a_1x^2+a_2x+a_3; \tag{8}$$

for simplicity let all the a's be unity, then

$$y=x^3+x^2+x+1 \tag{9}$$

$$=y_1+y_2+y_3+y_4, \tag{10}$$

where

$$y_1 = x^3 \quad \text{Cubical parabola,} \tag{11}$$

$$y_2 = x^2 \quad \text{Parabola,} \tag{12}$$

$$y_3 = x \quad \text{Straight line,} \tag{13}$$

$$y_4 = 1 \quad \text{Straight line.} \tag{14}$$

Fig. 5 results when these equations are plotted. The sum of the respective ordinates of these supplementary equations gives the corresponding ordinate of the graph of equation (9). It is evident that the graph of equation (8) cannot cross the positive x axis unless at least one term has a negative coefficient. The graph (Fig. 6) of

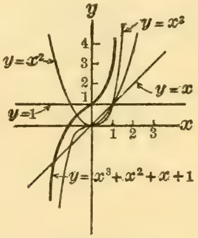

FIG. 5.

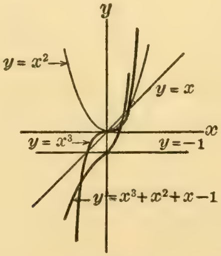

FIG. 6.

$$y = x^3 + x^2 + x - 1 \tag{15}$$

crosses the positive x axis once and has one positive real root. The graph may also cross the positive x axis once if the sign of the highest powered term is negative. If one of the intermediate terms is negative the graph may cross the positive x axis twice. The fulfillment of the mays depends on the relative magnitude of the coefficients. Fig. 7 shows the conditions which prevail for different values of the coefficient of the term of second degree in a typical third-degree equation.

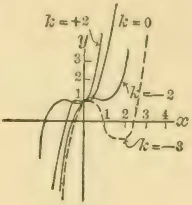

FIG. 7.

The graph of $f(-x)$ is an exact image, with respect to the y axis, of the graph of $f(x)$ since the odd-powered terms are reversed, accordingly it is the same thing all over again for the case of negative roots.

The Three Transformations.

I. *Diminishing the Roots by a Constant.*—The graph is shifted parallel to the x axis as is shown in most texts.

II. *Changing the Sign of the Roots.*—The graph is twice imaged, once with the x axis and once with the y axis. It is interesting to note that the two possible intervening images are merely the graphs of equations which are identical to the original and transformed equations except that one member is multiplied by minus one (Fig. 8).

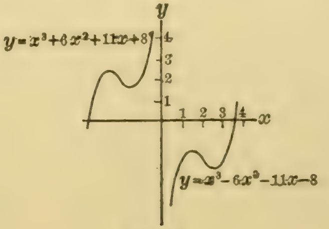

FIG. 8.

III. *Multiplying the Roots by a Constant.*—The graph is spread out in a rather complicated fashion.

Remainder Theorem.

$$f(x) = (Q(x))(x - a) + f(a). \tag{16}$$

The product in the right member is "multiplied" in the same manner as the factors of the quadratic and cubic equations were.

Consider for example the equation

$$y = x^3 - 6x^2 + 11x - 6 \tag{17}$$

$$= (x^2 - 2x + 3)(x - 4) + 6 \tag{18}$$

$$= (y_1)(y_2) + y_3. \tag{19}$$

The vertical distance between the graphs of $f(x)$ and $(Q(x))(x - a)$ will obviously be the remainder since it is the difference between the dividend and the product of the quotient and divisor. When $x = a$ the product of $(Q(a))(x - a)$ will be zero (as is stated in the analytic proof), as Fig. 9 shows. The remainder can be nothing else but $f(a)$ since it will be the ordinate of $f(x)$ when $x = a$.

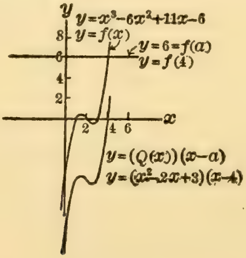

FIG. 9.

Partial Fractions.

Partial fractions are also amenable to a graphical demonstration.

$$y = \frac{4x-7}{x^2-5x+4} = \frac{1}{x-1} + \frac{3}{x-4}. \tag{20}$$

Fig. 10 contains plots of the original expression and plots of the two partial fractions. Each partial fraction takes care of one asymptote when the factors of the denominator are linear. Fig. 11 shows a case where one of the factors of the denominator is quadratic. Such a plot, besides showing that something is really connected up with the thing, is an excellent check on the work, since it is easy to note if the plots of the separate partial fractions add up to give the plot of the original expression. This check also insures that all the factors are prime, since if a quadratic term were factorable there would be two asymptotes "covered" by it.

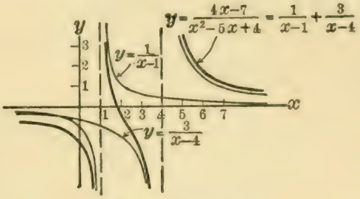

FIG. 10.

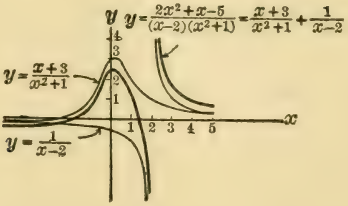

FIG. 11.

Certain problems, after having been solved, can sometimes be more readily explained if recourse to a figure is had. An example of such a case follows; the explanation will be apparent (Fig. 12).

"A ship is twice as old as the boiler was when the ship was as old as the boiler is now. When the boiler is as old as the ship is now the sum of their ages will be 56 years. Find their present ages."

Solution:

Let $x =$ the present age of the boiler.

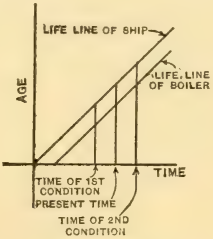

FIG. 12.

And $y =$ the present age of the ship.

Equation for the first condition:

$$y = 2(x - (y - x)), \tag{21}$$

$$3y = 4x. \tag{22}$$

Equation for the second condition:

$$(y + (y - x)) + y = 56, \tag{23}$$

$$3y - x = 56. \tag{24}$$

Substituting equation (22) in equation (24) gives

$$4x - x = 56,$$

$$3x = 56,$$

$$x = 18\tfrac{2}{3}.$$

Age of boiler $= 18\frac{2}{3}$ years.

Substituting this value in equation (22) gives

$$3y = 4(18\tfrac{2}{3}),$$

$$y = 28\tfrac{1}{3}.$$

Age of ship $= 28\frac{1}{3}$ years.

Complex numbers, determinants, progression, logarithms, empirical equations and the convergence of series have graphical significations which greatly aid students in getting an understanding of them. Geometric probability is also a much neglected thing which should be rejuvenated.

It is to be expressly noted that it is not intended to parade all these things as methods of solution. Their main purpose is to aid in explanation, *i. e.*, in giving the student a concept.

In actual engineering work data is taken and plotted. Perhaps a mathematical expression is manufactured to replace it and then the expression is manipulated according to the taste and ability of the engineer. Great assumptions are often made in order to have a workable expression. In many cases it is a question if something akin to the foregoing could not be directly applied to the original plot with improved results. It seems quite certain that less difficulty would be experienced in interpreting experimental results if students of science were trained to ''feel'' mathematical operations. This possibility and the fuller mathematical understanding given to the student seems to be ample justification for introducing such graphical work in algebra.

LOCAL SOCIETY MANAGEMENT DEMANDS MORE CONSIDERATION.*

BY C. E. DRAYER,

Secretary, Committee on Engineering, Coöperation, Cleveland.

MODERN STRUCTURAL PRINCIPLES OF GROUP ACTIVITY SHOULD GOVERN ORGANIZATION AND METHODS OF ENGINEERING SOCIETIES—CHOOSE OFFICERS WITH CARE.

At a time when the local engineering society is gaining so rapidly in recognition and influence but is still in the formative state it seems desirable to consider more fully than has yet been done some of the principles which should govern its organization and management. The subject is so broad that only a few features common to all local societies can be considered.

Often when a society is being organized much time is spent uselessly in framing a long constitution calculated to meet all future conditions. This presumes that the members of the society in the coming years will not be mentally equipped to care for situations confronting them. It indicates also an attempt to foresee the lines along which the future activities of the society is a mobile, flowing thing, serving its purpose best when allowed the greatest latitude to conform to the will of its members. The ideal constitution should embody organization structural principles only and provide for nothing except members, officers and money. Details should be left to by-laws, which should be few and easily amended to meet changing conditions. A long constitution tempts parliamentarily inclined members to epidemics of revision. No constitution can insure interest and loyalty, from which spring enthusiasm and initiative.

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Broadly speaking, a society exists to do what the individual cannot do—develop its members to become successful both in the practice of their profession and in all their duties as citizens. This implies class consciousness. Other classes—doctors, lawyers and labor men—have demonstrated for years the value of acting in unison. Every engineer who has thought carefully on the subject has voiced the conclusion put in practice long ago by other classes, that unity is primarily within the province of the local society. State and national unity are merely larger measures of local unity.

Responsibility for the conduct of the society centers in the president and his immediate advisers, in whom the various lines of activity are harmonized. Careful provision should be made against choosing for officers men whose claim to the honor rests on distinction attained in the practice of the profession rather than wise and untiring leadership in the society. Equal care should be taken to guard against perfunctory, haphazard or clique choice. Probably the best way is to have a standing nominating committee whose business is to study constantly the growing timber in the membership and see that only those are put up for office who show true leadership, not mere persistence in work. Creative imagination, ability to interpret the heart, to say clearly what his fellows feel and to inspire loyalty, are necessary qualities for chief officers.

If a society has sufficient income to hire an executive secretary, a great deal of thought should be given to his selection, for on him perhaps more than on even the president rests the chance for success. The president usually changes each year, but the secretary may continue for many years. Prominent among the qualities desired in the secretary is vocational aptitude, which comprehends pleasing personality, ability to converse in a convincing manner and the power to stimulate the individual member to do his part. In no small measure the society will fulfill its mission if the individual member can be made active. An analsis of almost any society voluntary in character will reveal that its strength, its organized coöperation, is due to loyalty to some individual. Fortunate is the society that can pay this tribute to its secretary. Such a man has the incentive of his own success coupled with that of the society to become familiar with the laws of modern group activity, developed from the experience of successful organizations. He should be of the caliber to be trusted with authority not only in the business management of the society but to represent it in the absence of the chief officers in those delicate civic relations where even the right may lose if not tactfully presented.

Committees are divided into standing and special. The former have to do with the regular business of the society, such as property, finance, program and membership. The latter are created to care for special problems from time to time and exist until their work is completed.

A society member once facetiously remarked that he had been on a committee for two years but never found it had committed anything. A strong executive has been credited with defining an effective committee as composed of three men with one member out of town and one dead. Both remarks have been widely cited as a way of saying that it is an unusual committee that does continuous and effective work. The fault is not so much with the committee as with the kind of work expected of it, composed as it is of men who have numerous and important duties outside of the society.

It would be better to recognize a committee as mainly a deliberative and advisory body which must be provided with machinery to carry out its findings. This is usually done by the chairman or by a secretary provided for the purpose. The average civic-commercial body, such as a chamber of commerce, usually has sufficient funds to provide the necessary secretarial assistance—and herein lies the reason for the amount of work done by the committees of such bodies. If the younger engineer can be found with time at his disposal to act as committee secretary, it will take from the busy older men routine detail and afford the youngster a fine opportunity to gain experience and make useful acquaintances. There is no more valuable asset for the engineer at the threshold of his career than a favorable acquaintance with the leaders of the profession.

Competent Chairman Gets Results.

The surest way to get a committee that produces is to place at its head a man who is competent and will work. The head of a great business recently said: ''The secret of organization is to pass the buck to the right man and see that he does it.'' Courtesy has thus far prevented any president of a society from removing the chairman of a committee because he stagnates. Detail management takes time from the president already burdened with work. A suggested solution tried with success more than once is found in a steering or managing committee whose duty is implied in its name.

Of the standing committees none is more important than the program committee. Despite the usual limitation of funds, a strong program of diversified interest must be presented. What does the membership want and what does it need? We can discourse at length on the duty of each engineer to support a local society for the good of the profession and the good of the community, yet fall short if we fail to realize that the altruistic appeal is second to the selfish. The society must give service liberally to pay the average member for his outlay of time and money. Provision must be made to supply the papers on the latest theory, design and practice. The program committee or a similar one must provide the opportunity for the membership to gain the benefits that arise from personal contact and social intercourse. Smokers where the technical gives way to stories that melt the ice of diffidence must have a place. It must be recognized that the engineering society is in competition with other civic organizations. Hence the old style of society must give way to a program of action frequently recast and vitalized by innovation.

The most important membership asset of the society is the young man. It should be easy for him to find himself a member even while an undergraduate. He should be trained assiduously in the way he should go in organization work. Inasmuch as he is anxious to prove himself in his life work, provision should be made for him to gain recognition for meritorious work in the society. Some societies provide a junior grade in which the charge to the young man is lower than the cost to carry him as a member.

Apply Test of Usefulness to Activities.

Among the early ambitions of all societies is the desire to obtain permanent quarters, establish a library and start a publication usually called the ''Journal.'' The desire is to give the society a physical body, a material evidence of existence. Even the sacred institutions of library and publication should be compared unflinchingly for usefulness with other activities in which the society may engage. Unless there are funds for adding new books and for cataloguing in public library fashion to make the library a working tool, the society had better acknowledge that its boast of a library is empty and make arrangements with the local public library to make the books useful. Such arrangements have been made by two local societies. Reference work of the average member is more to articles in current technical magazines than to texts, hence nearly complete files of current technical magazines are a necessity. Bound periodicals dating back say five years and the latest and best books in the several engineering fields might well constitute the working library of the local society. One large local society maintaining perhaps the largest library of its kind in the country found that it could present to each member asking for a book an order for the purchase of the book and come out ahead financially at the end of the year.

The ''Journal,'' as published by several societies, may be defined as a publication in which papers presented before the society are preserved in permanent form and is differentiated from the ''Bulletin,'' published rather frequently and partaking more of the character of a news sheet. In a recent observation it was found that not more than 10 per cent. of the members examined the journal with care or read some of the articles. It would be an instructive experiment to place the journal on its own footing, making a budget to include voluntary subscriptions and other income, and charging against it all legitimate costs, including proportion of office expense and overhead. In suggesting such a study it is recognized that not every activity can be expected to pay its way. For instance, no one concerned in club management has been discovered by the writer who could make the dining room pay its way. Yet a club without dining facilities is hardly a club.

The Need of Cost System.

The above remarks directed to time-honored institutions of engineering societies implies that a cost system should be set up if the same efficiency in the use of money is to be approached as is reached by many members in their factories. Most societies make a budget, but none has said, for instance, how much it costs to collect dues and conduct the other activities that absorb a large part of the time of paid assistants. A successful manufacturer knows to the hundredth of a cent what his costs are, but an engineering society goes along blithely until the money is gone; then it raises dues or curtails necessary work. The annual incomes of several local societies pass the $10,000 mark. It would be well to have a standard system of cost accounting so that the results attained in one society could be compared with those of others.

SOURCES OF GOVERNMENT INFORMATION CONCERNING THE WAR.

Owing to the enormous increase of government war work, the governmental departments at Washington are being flooded with letters of inquiry on every conceivable subject concerning the war, and it has been found a physical impossibility for the clerks, though they number an army in themselves now, to give many of these letters proper attention and reply. There is published daily at Washington, under authority of and by direction of the President, a government newspaper—The Official U. S. Bulletin. This newspaper prints every day all the more important rulings, decisions, regulations, proclamations, orders, etc., as they are promulgated by the several departments, and the many special committees and agencies now in operation at the national capital. This official journal is posted daily in every postoffice in the United States, more than 56,000 in number, and may also be found on file at all libraries, boards of trade, and chambers of commerce, the offices of mayors, governors, and other federal officials. By consulting these files most questions will be found readily answered; there will be little necessity for letter writing; the unnecessary congestion of the mails will be appreciably relieved; the railroads will be called upon to move fewer correspondence sacks, and the mass of business that is piling up in the government departments will be eased considerably. Hundreds of clerks, now answering correspondence, will be enabled to give their time to essentially important war work, and a fundamentally patriotic service will have been performed by the public.

April 16, 1918.

EDITOR, BULLETIN OF THE SOCIETY FOR THE PROMOTION OF
ENGINEERING EDUCATION.
UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

My dear Sir:

I am taking the liberty of sending you a brief notice regarding the Official U. S. Bulletin which I hope you may be able to use in the immediate future. Everything possible must be done at this time to relieve the governmental departments at Washington of the enormous amount of work imposed upon them since our entry into the world war. The notice I am sending you is self-explanatory, and I feel that much good will be done the government if this matter is given the widest publicity possible.

Please call on us if we can be of any service to you.

Very sincerely yours,

E. S. ROCHESTER,
Editor.

EDITORIALS.

Scholarship.—The editor was present at a meeting of college presidents a few months ago at which time an address was made by the president of a noted eastern university. He stated that as a result of the war courses, the faculty has discovered that students would study and work if they are interested. The tendency for engineering students to become so absorbed in their work that they neglect to give to the college social and athletic activities proper attention has been of long standing and during the last few years has been much discussed with beneficial results.

The war has taught many outside the above-mentioned university that a young man may be trained mentally without detriment to his social development while in college. Scholarship is not incompatible with breadth of view or a desire to take a normal part in college activities. In fact, the latter should be so regulated that sound scholarship is essential to participation in them. Anyone who has had the opportunity of becoming acquainted with the kind of men who are required to fill the responsible position in this war will appreciate the fact that sound scholarship is an essential prerequisite for their preparation in the war work.

The report of the special committee of the Cornell University faculty should be considered by every engineering school faculty.

The 1918 Meeting.—The twenty-sixth annual meeting comes when we are in the midst of a great war. Most of us have so many additional duties that it seems hardly possible that we can take time even to attend such a meeting to say nothing of taking part. However, the government has made extensive demands upon the engineering schools and they are meeting these demands in a way that is worthy of their past history.

Surely much benefit can be derived by the schools as well as by the members of the faculties if we gather for a few days for a discussion of the many problems which now confront us.

BOOK REVIEWS.

Infinitesimal Calculus. Section II. By F. S. CAREY, University of Liverpool. Longmans, Green and Co., New York. 1918. x + pages 145 to 352. $3.00.

The first section of this book appeared in 1917. This one contains Chapters XII to XX with Appendices I to VI inclusive. Some of the subjects treated in an interesting manner are tangential polar equations, intrinsic equations, point-roulettes, line-roulettes, the general motion of a lamina in its plane, nomograms, the hexagonal abacus, and the parallel abacus. There is a chapter on differential equations, and answers to the numerous problems are given at the end of the book.

F. A. F.

Elements of Machine Design. By O. A. LEUTWILER, M.E. McGraw-Hill Book Co., Inc., 1917. 6½ × 9¼. 607 pages. $4.00.

The author has presented the elements of machine design compiled in a very thorough and up-to-date manner. The work contains the principles, facts, formulas and data necessary in the modern theory and practice of machine design. All subjects under discussion are well illustrated with drawings of modern machine parts.

The book is a very good text for the student and a valuable reference for the engineer or designer.

W. W. B.

Fundamentals of Illumination Design. Issued by the ENGINEERING DEPARTMENT, NATIONAL LAMP WORKS, Nela Park, Cleveland, O.

This bulletin is an excellent one for the practical man. The entire pamphlet, consisting of sixty-five pages, is expressed in a simple and apprehensive manner. It is written in popular language, higher mathematics and advanced science is entirely omitted. It is adapted to the requirements of those engineering students who should acquire a brief knowledge of interior lighting but have not the time to spend taking a complete course in illuminating engineering. The book is probably the best of its kind and size. This booklet is divided into four parts, dealing with the following phases of illumination: photometric units and distribution curves; reflectors, shades and glassware; principles of interior illumination design; and solutions of practical problems.

J. E. K.

BULLETIN

OF THE

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AN EXPERIMENT IN TEACHING.

BY F. G. HIGBEE,

Professor and Head, Department of Descriptive Geometry and Drawing,
State University of Iowa.

What is the best method of presenting facts to students?

Do they learn more quickly by studying from a text-book, or by hearing this same subject-matter explained by an instructor and illustrated on the blackboard?

The following data are presented here in the belief that they throw some light into this rather obscure angle of teaching.

The Problem.—The subject-matter to be learned was a proposition in descriptive geometry involving a definite principle. Since no text contained an explanation of this principle it was *necessary* to resort to the method of a blackboard demonstration.

The Method of Teaching.—In presenting the problem to the students it was first very carefully stated and the given conditions and required results thoroughly explained. Using the given data a demonstration was then presented accompanied by an illustrative figure on the blackboard which was built up line by line as the demonstration proceeded.

After several class periods had elapsed, and ample time for study had been given, an examination upon this principle was given.

As would be expected, some students failed to pass this examination—failed, in fact, to understand the principle which had been the subject of the lecture. These students were then required to work out this principle under supervision until it was thought that they understood it. Following this a second examination was given. Both those who had passed the first examination and those who had failed it were required to take this second examination.

This same process, covering each time the same principle, was repeated for four or five examinations, and with three different groups of students during three different years.

The Result.—The curve, Fig. 1, is a composite. It illustrates the general result for all groups rather than the exact result of the tests of any one group. It very accurately expresses, however, the results obtained from this method of instruction. Vertical distances represent percentages of the class *not passing* any given examination, horizontal distances represent both the number of opportunities, or examinations, and the time allowed for preparation.

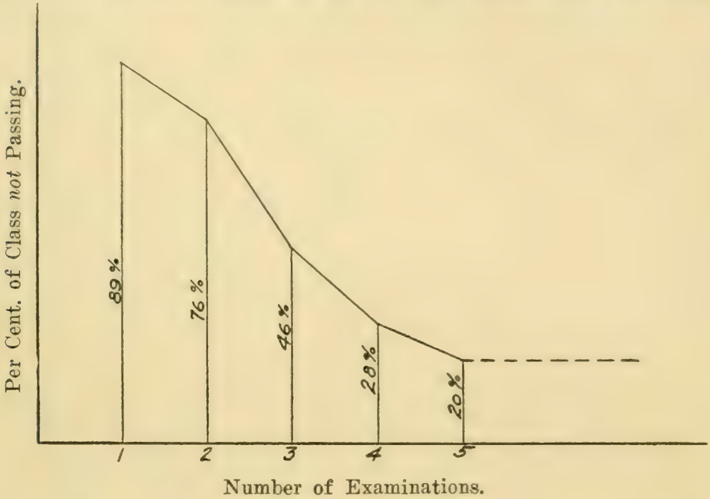

FIG. 1. Result by Lecture Method. Note: Intervals between examinations were seven days.

In general, it will be noted that about twenty per cent. of the class never mastered the principle involved, and that it required about four trials before that portion of the class which could master the principle actually did master it.

This, let it be remembered, was the result of the lecture method. Let us now examine the effect of teaching by textbook without the lecture.

The Problem.—At this time a text was adopted for use which contained a complete explanation of this principle which was proving so difficult for students to understand.

The statement of the problem, the given and required data were identical, and the method of explanation in the text was the same as that followed on the blackboard. The only differences between the method of presenting the subject-matter were these—in the text the student was presented with a figure which was complete, on the blackboard the illustrative figure was built up line by line. Otherwise the presentation was the same except that the method varied.

The Method of Teaching.—The problem was assigned as a lesson. No explanation concerning it was given other than that the problem was important and required careful study. Opportunity was given for students to ask questions and to clear up any doubtful points. After sufficient time had elapsed an examination on this problem was given.

As in the first experiment some students failed, a much smaller proportion of the class, however. These were coached and given further opportunity to master the principle, then a second examination was given to all students. This same process was repeated until a total of three examinations had been given.

The Result.—The curve, Fig. 2, is the exact record of what happened in one class. It will be observed at once that those students who could master this problem demonstrated this fact on the first trial, and that those students who could not pass the *first* examination never succeeded in mastering the principle. Other groups of students were tested in a similar manner with similar results. While the curve in Fig. 2 is the exact record of one group it is also a typical record of class performance under this system of instruction.

Conclusions.—The conclusion to be reached from these two experiments is so obvious as to require no exploitation. Briefly stated it is this—the method of presenting facts to students by the lecture system is inferior to the method of presenting facts by the text-book system.

Students are not capable of taking notes, are not able to remember demonstrations without notes, and are not developed mentally to the point of being able to assimilate facts at one hearing.

Given a text in which the matter to be learned is clearly stated, students will devote sufficient time to the study of these facts to overcome their individual handicaps in rates of learning. The proof of this is shown in Fig. 2.

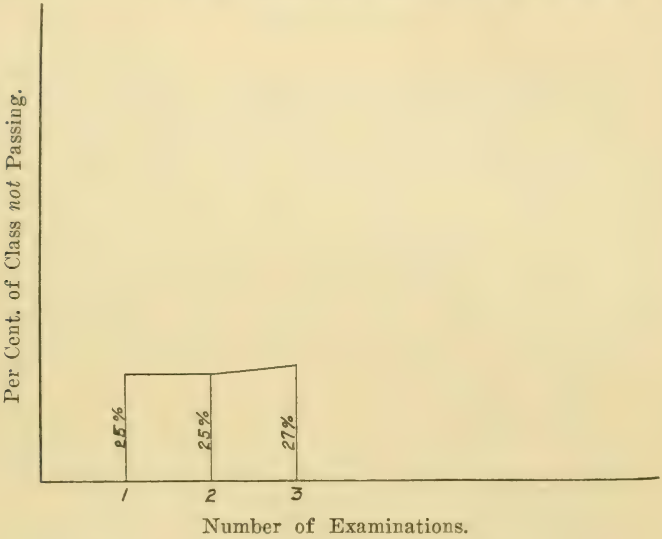

FIG. 2. Result by Text Method.

After sufficient time for study, a class will demonstrate, if taught by the text-book method, in *one* trial that they have mastered the lesson. It requires from three to five trials to reach the same state of class perfection when the instruction is by the lecture method.

STIRRING UP DRY BONES.

BY JOHN S. CRANDELL,

New York City.

If a business man wishes to introduce a new department into his factory, into his office, or into any branch of his particular industry, he seeks out an expert in that line and turns over the organization of the department to him. That expert must produce results with untrained men; and to produce results he must be able to teach his force. He must be able to teach them thoroughly and well. And to teach them he must know his subject perfectly. If he is not able to do this his men will not respect him, cost of production will be high, the product of his department will not be salable, and he will soon find himself without a position.

Business men know this, and therefore take pains to secure men who are trained and able to handle particular propositions. This is one of the secrets of Big Business.

It is high time that our colleges and universities follow suit. In fact they should have led the way in this direction. Instead, for the most part, they have pursued just the opposite course, so that we have the spectacle of hundreds of instructors attempting to teach subjects of which they have but the slightest knowledge.

At the present time there is a demand for highway engineering courses. Yet how many of the men now teaching the subject, or who will be required to teach it this coming year are thoroughly qualified to do so? Probably not a dozen in the country! For, to properly teach highway engineering a man should travel very extensively, and obtain first-hand information on every phase of the subject, and this the salary of the average teacher does not allow.

The usual procedure is to inform some man who is teaching railroad engineering that he is to teach highway engineering as well, it being taken for granted that the two are very intimately related. Often, far too often, the man teaching railroads has obtained his information, or the most of it, from books, and he knows little of actual railroad work. He is doubly handicapped, then, when he endeavors to teach highway work as well.

How many of those teaching highway engineering have ever put in real hours in bituminous laboratory work, in stone and brick testing laboratory work, and in actual road construction? And of those who have done all this how many can teach?

What has been said applies to nearly every course that is given in a technical school. The writer has seen men put to teaching geodesy who knew nothing about it. Others he has seen teaching structures who never had erected a bridge, or watched one being erected, or worked in a bridge drafting room. Others he has known who, at short notice, have been obliged to teach courses in astronomy whose only qualification for the work was that they could pick out Polaris with some degree of certainty. And so on indefinitely: men teaching hydraulics and sanitation whose life work has been in entirely different fields; young recruits put to teaching all sorts of subjects of which they themselves had but the merest smattering of knowledge; and one instance in particular where a professor of geology had to teach psychology when the funds of the college were low!

Often one can hear young instructors telling how they are just one lesson ahead of the class in some subject. And they seem to think that they are "putting one over" on the students! Have they never listened to the remarks that the students make about them? Do they never remember their own feelings on just such matters in *their* student days? Do they really imagine that they are really "getting away with it?"

When a man is set to teaching something he is not qualified to teach, the gain is his, and the loss is the students'. A man certainly cannot teach a subject without learning a great deal about it, but while he is learning what he should have known, his students are suffering from his lack of knowledge.

And how bitter are the thoughtful among those students in later life! They feel that they were cheated; that they sat at the feet of men who knew but little more than they did, if as much; that the hours spent were wasted. Nor can these same men praise highly enough those who knew their subjects and really taught them something.

Let us see where the trouble is; let us look at the matter from the viewpoint of the instructor, and from that of his superior officer.

A young man decides that he wants to teach in a college. He is a graduate of a technical school, and he may have had a year or two of practical work in some highly specialized line. He hears of an opening, applies, is interviewed, and is hired. He is given his schedule and finds that he has about 20 hours a week, maximum. He probably has two or three subjects to teach that he vaguely remembers having pursued in his freshman or sophomore years. He starts in and soon finds that he has a great deal of time on his hands, for his 20 hours a week are really only two days' work if the hours were bunched, as they would be in business. By a little application he can keep ahead of his classes so as not to be caught napping. He receives no instruction from his superior how to teach, when a few practical hints from an experienced teacher might go a long way toward making a better instructor of him. He is largely left to his own devices. For the not over-ambitious average man this spells rust and decay. The easy life, the seeming lack of responsibility, and the frequent and long vacations all tend to cause a young man to do as little as he can. Teaching is often either a lazy man's job, or a stepping stone; in both cases the college suffers. At this period of his life the young man cannot see graduates returning, laughing at him, or openly sneering at him; for nowhere is the saying "As ye sow'' as true as in teaching college men. He does learn considerable of the subjects he is teaching, but it is mostly book knowledge. In time, if he sticks, he may turn out to be a fair teacher of book-taught information. And then again there may be an irate committee of students appear before the Dean or the President and demand the removal of the young man as an incompetent!

During summer vacation he ''rests.''

The head of department in hiring new men has great difficulty in obtaining suitable material. He has only a small amount of money at his disposal for salaries, and therefore cannot hope to attract big men; he may be pressed for time, some one has resigned just before the term opens and he has to take the best that offers itself; he cannot tell a man's teaching ability at sight; he will give the man only elementary subjects, anyway, and somehow he will get by. And oftentimes the head of department knows as little about practical things as the man whom he hires. So he ''takes a chance'' on the young man ''taking a chance,'' and the students get their chance at ''taking a chance.''

A man in the ordinary course of business life works at least eight hours a day, or 44 hours a week. If he had to work but twelve or fourteen hours a week, as many of the members of our faculties do, he would think the millennium had come. As a matter of fact many of our successful business men work nearer 18 hours a day than 8.

Now the remedy. Double up the number of working hours, double the salaries, and cut the faculty in half. Engage men who are thoroughly versed in two or three specialties; men who are experts in the subjects they teach; keep them teaching those specialties. This is an age of specialties. Require, as part of their contract, that these men spend two months in the summer in actual work on one of their specialties, changing the work each summer. This will leave a month's vacation, or two weeks more than most men get, to say nothing of the numerous vacations during the year. Engage no one who has had no practical experience in the technical work he is to teach. Turn the drudgery of teaching, *i. e.*, correcting papers, laboratory preparation, and the like, over to men hired for that purpose, as far as possible. These men may be considered as apprentices in teaching, who, after they have had practical experience, may become regular members of the faculty. Men new to teaching should be given some of the fundamentals of pedagogy. Not all the bosh that is fed to normal-school students, but a few well-chosen principles of teaching. A natural born teacher needs no more: others should not be teaching.

With a good salary a good man can be hired who will not mind teaching 35 or 40 hours a week any more than he minds working that length of time at the practice of his profession outside the college walls. With such men as teachers the product of our institutions will improve immensely, and students will find it an inspiration instead of a drudgery to go to college.

FURTHER CORRELATION IN ELECTRICAL ENGINEERING.

BY C. FRANCIS HARDING,

Professor of Electrical Engineering, Purdue University.

"Intensive training" is the by-word of the day during this military crisis. Many experimental changes in the administration of university work, undertaken during this period, will no doubt prove of such value in times of peace as to find a permanent place in the curricula of technical institutions. One change in the school of electrical engineering at Purdue University seems to meet such a need as judged by experience to date.

It has been felt for a long time that most efficient university instruction is impossible with a student class schedule involving a large number of varied subjects, each of which brings a student before a given instructor but three times per week or less. To use electrical phraseology, why not administer more intensive courses in series rather than short hour courses in parallel?

In order to give such a principle a fair trial and to correlate further the theoretical study of electrical machinery with the laboratory tests upon the very apparatus being studied in class at any one time, the schedule of subjects in the curriculum was completely rearranged during the present year. The difficulty of such a plan, especially with large classes, results from the necessity of having on hand several sets of machines of similar type in order that several groups of students may be testing one type of machine at the same time. Experience has shown, however, that even in cases where the number of students in a squad must be increased to six or eight or, in extreme cases, where a demonstration test must be provided for an entire section of twenty men with different students taking individual readings, the benefits of absolute correlation with class-room work more than outweigh any such handicaps of administration.

Such a plan may offer less opportunity for formal laboratory reports, many of the results and characteristic curves being worked out during a demonstration period. Often the ways and means of testing a given machine may occupy the preceding class-room period while the results of the test form the subject-matter under discussion at the subsequent recitation. The desired training in writing complete engineering test reports is provided for in the second semester of the senior year in a laboratory test course undertaken after the combined laboratory and theoretical course on electrical machinery has been completed.

During the past semester more ground was covered in a more thorough manner with a course consisting of five hours per week recitation and three hours laboratory, all in charge of the same instructor and carrying a single grade, than has been accomplished in past years with a three-hour course with disassociated laboratory work continuing for a full year. In the junior year a course involving six hours per week was possible.

These results cannot be attributed to any endeavor on the part of either instructors or students to anticipate a possible February commencement, for such was at no time contemplated. With the engineering reserve ruling in operation in response to a desire for a complete technical training on the part of prospective military officers, there seems to be less occasion for the early commencement than seemed to be the case at first.

As the demands of the year have developed, it is particularly fortunate that this plan was adopted. Seniors are now able to undertake the special courses prescribed by the Signal Corps, U. S. Army, during the second semester with no curtailment of other than elective subjects. Ninety per cent. of the seniors in electrical engineering are availing themselves of the opportunity of specialized training in this branch of military work for which the electrical engineering student seems to be particularly well qualified.

The courses in electrical machinery for the non-electrical engineers have undergone a similar change and since these involve relatively less time, the results are fully as favorable. Let a graduate engineer attempt to focus his attention upon ten or twelve different engineering and economic problems requiring intensive study and concentration, and further assume that he is obliged every fifty minutes to stop where he is and attack another problem having no connection with the former. He will at once appreciate by way of contrast, the value of the series over the parallel schedule of subjects in the university curriculum.

THE ENGINEERS' SYSTEM OF MECHANICAL UNITS.

BY WM. S. FRANKLIN AND BARRY MACNUTT.

The essential difficulties which must be met and overcome in the teaching of elementary mechanics are very great, and all difficulties which grow out of non-essentials should be completely eliminated. It is therefore quite intolerable that any disagreements as to terminology and units should now be left outstanding.

The chief obstacles to agreement in the past have been (1) an unreasonable and mistaken contempt on the part of the physicist for the engineers' system of units, (2), the fact that a particular engineer or engineering teacher is interested only in a partial use of the system, and (3) a failure among many teachers, of physics and of engineering, to understand that precision of definition and precision of thinking is not the same thing and in no way dependent upon or mixed up with numerical precision.

We confess that we have been guilty of the above-mentioned contempt, unreasonably and mistakenly, and we trust that this confession on our part may qualify us to speak of the remaining obstacles (2) and (3) without offense.

The term *mass* means quantity of material as measured by a balance scale, and it is properly expressed in grams or pounds. In commerce, however, we speak of the *weight* of a batch of sugar or coal as *weighed* by a balance scale, and the word *weight* so used means exactly the same thing as *mass.*

Technically the *weight* of a body means *the force with which the earth pulls on the body*, and it may be properly expressed in dynes or poundals. The pull of the earth on a one-pound body in London is a definite force, for many purposes it is the most convenient unit of force, and it is called the "pound." The weight of a body, that is to say, the earth-pull on a body may be properly expressed in "pounds" *but the coal man's scales do not determine the weight of a body in "pounds."*

One "pound" of force gives an acceleration of 32.174 feet per second per second to a mass of one pound, so that according to Newton's second law, one "pound" of force will give an acceleration of one foot per second per second to 32.174 pounds of material (one *slug* of material) Therefore if force is expressed in "pounds," mass in slugs and acceleration in feet per second per second the simple form of the equation $F = ma$ can be used.

To reduce pounds of coal as measured by a balance scale to slugs, divide by 32.174 (a pure number, *not* an acceleration). The weight W of a body (the force with which the earth pulls a body) is of course equal to mg, so that the mass of the body m equals W/g. Thus the actual local weight of a body *in London "pounds"* divided by the local value of g gives the mass of the body in slugs*; but when your coal man sends you a bill for what he calls a certain *"weight"* of coal, say 2,000 pounds, do not divide this kind of "weight" by b to get mass!

The system of mechanical units which involves the "pound" as a unit of force is very widely and properly used, and every teacher of elementary mechanics should use this system of units unhesitatingly. We call the system the *foot-slug-second system* in order to differentiate it sharply from the *foot-pound-second system.* There is no objection to the precise use of the foot-slug-second system except on the ridiculous assumption that the primary business of the teacher is to promote the metric system; but it is improper for anyone to agree to use the word *weight* for the force with which the earth pulls on a body and then carelessly revert to the usage of the grocer and the coal man.

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* A perplexing mix-up of dimensions is involved in the double meaning of the word pound. Out of respect for etymology we may postulate identical dimensions to the pound of sugar and the "pound" of push or pull, or we may postulate identical dimensions to pounds of sugar or slugs of sugar. We prefer the second postulate, and, in accordance with this postulate, one must divide pounds of sugar by 33.174 (a numeric) to get slugs of sugar, and one must divide the local weight of a body in London "pounds" by the local acceleration of gravity (a denominate number) to get mass in slugs. From this point of view the "pound" of force has the same dimensions as the poundal of force.

The weight of a body in London in "pounds" is, of course, equal to its mass in pounds, and it has, more than once, been proposed to call the weight of a body in London its *standard weight* and use the term *standard weight* instead of *mass;* but there are two objections to this, namely, (*a*) the term mass is almost universally recognized by physicists and chemists, and (*b*) the mass of a given body is independent* of time and place, it has to do only with an invariant* relation between the given body and the standard kilogram (a piece of metal), and extraneous and confusing ideas would be introduced by the use of the term *standard weight* because this term implies location and a relationship between the given body and the earth. How awkward it would be, for example, to be obliged always to speak and think of the distance d between two points (x, y, z) and (x', y', z') as $[(x-x')^2 + (y-y')^2 + (z-z')^2]^{\frac{1}{2}}$. This is an invariant and the most useful name or symbol for it is a name or symbol which carries no redundant suggestion as to particular axes of reference, *and this would be true even if we had always to make use of a particular set of reference axes in the measurement of d.*

The units of any system can be used in any equation in mechanics (including hydrostatics and hydraulics) if the equation is in its simple generalized form.

Example 1. $F = ma$, where F is in "pounds," m in slugs and a in feet per second per second; or where F is in poundals, m in pounds and a in feet per second per second.

Exmple 2. $W = 1/2\ mv^2$, where the kinetic energy W is in foot-"pounds," m is in slugs and v in feet per second; or where W is in foot-poundals, m in pounds and v in feet per second.

---

* No consideration is here given to variations of mass as recognized in the recent developments of the principle of relativity.

Example 3. $T = K\alpha$, where α is the angular acceleration of a wheel in radians per second per second, K is the moment of inertia of the wheel in slug-feet^2 (or in pound-feet^2) and T is the accelerating torque in "pound"-feet (or in poundal-feet).

Example 4. In testing a piece of steel the weight of 10,000 pounds of material is applied to the piece. The force is 10,000 g poundals or $(10{,}000 \div 32.174)\ g$ "pounds," where g is the local acceleration of gravity. *For all practical purposes the difference between* $(10{,}000 \div 32.174)g$ *and* 10,000 *is entirely negligible in this kind of a test, and therefore many engineering teachers are led to think that it is mere affectation to insist on a precise definition of the "pound" of force as the pull of the earth on a one-pound body in London.*

Example 5. $p = ldg$ where p is the pressure in "pounds" per square foot (or poundals per square foot) at a point l feet beneath the surface of a liquid of which the density is d slugs per cubic foot (or pounds per cubic foot) at a place where the acceleration of gravity is g feet per second per second.

Let us repeat. There is no generalized equation in mechanics (including hydrostatics and hydraulics) in which f. s. s. units may not be used, but the coal man's pounds must not be divided by the local value of g to give mass in slugs. The expression $W = 1/2g.mv^2$ for the kinetic energy in foot-"pounds" of a moving body of which the mass is m pounds and the velocity is v feet per second is incorrect and misleading. Of course, ignoring dimensions of g, it is accurate enough for all practical purposes; yet, but the most important practical thing in this world is clear and precise thinking, and for purposes of thinking the equation $W = 1/2g\ mv^2$ is simply out of the question.

It always amuses us to hear an engineering teacher express contempt for the poundal as a unit of force, and we use the poundal chiefly as a name for a step in an argument. It is better to name it than to refrain from naming it, thereby pretending not to use it. Everyone who expresses mass in pounds does use the poundal as a unit of force, and every English-speaking person expresses mass in pounds when he buys sugar or coal. If a man steals sugar no accounting is necessary, at least no book-keeping is necessary, and only such men among English-speaking people can honestly claim not to use the poundal as a unit of force. The question would appear therefore to be a question of honesty versus dishonesty, but it is not quite as bad as that, for the second horn of the dilemma may be unconscious dishonesty or sophistry, and this unconscious dishonesty is carried to the limit by a recent writer who speaks of the coal man's unit of mass as scholastic.*

Several years ago one of us pointed out the most troublesome fallacy in elementary mechanics in a discussion of Professor Maurer's S. P. E. E. report on mechanics, namely, the agreement to use the word *weight* for the gravity pull of the earth on a body and the subsequent reversion of most of our engineers and engineering teachers to the usage of the grocer and the coal man! If agreements are made let them be lived up to.

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* Professor E. V. Huntington, of Harvard University. See *American Mathematical Monthly,* January, 1917, page 16.

PRELIMINARY REPORT OF COMMITTEE NO. 12, ENGLISH.

In continuation of the committee's work for this year, the following questionnaire was sent to teachers of English in one hundred technical colleges in the United States:

TO THOSE WHO ARE INTERESTED IN THE TEACHING OF ENGLISH TO ENGINEERING STUDENTS.

Committee No. 12, Society for the Promotion of Engineering Education, has received instructions to continue the study of the present status of instruction in English for engineering students.

In carrying on its work of investigation, the committee seeks the coöperation of all who are interested in this phase of the engineering student's training. It is believed that the time has come for a new and a definite statement of the place English should have in the general scheme of engineering education. During the present year, by reason of their new relation to the War Department, engineering colleges have been given increased responsibility as well as added prestige. Many of them have already begun to scrutinize their curricula and to weigh the respective claims of the various subjects now scheduled. The forthcoming report of the Carnegie Foundation for the Advancement of Teaching will serve both as a guide and as a stimulus to further self-analysis, and will evoke a general discussion of the relation of each subject to an entire program of professional training for engineers. The committee feels that teachers of English, along with teachers of other subjects, will be benefited by this challenge for a restatement of their point of view, and for a vindication of the claims of their particular branch of study.

As a modification of the usual questionnaire, the committee has adopted a plan, which, it is hoped, will elicit a more complete expression of experience and opinion than is possible in a tabular arrangement of questions and answers. Recipients of this letter are requested to indicate on the enclosed duplicate, pages 214 and 215 from the Proceedings of the Society for 1917, the following information.

Part I.

1. *English as a guarantee against illiteracy among college graduates.*

   a. Typist English: review of elementary grammatical and mechanical forms, to make up for inadequate preparation of entering students.

   b. A constant check upon the writing of students during their course, in order to cultivate habitual correctness of form.

   c. Heavy penalties for mistakes, and refusal of degrees to incorrigible illiterates.

   d. Reading and study of literature, especially the classics, chiefly for the sake of familiarity with what educated people are expected to know.

   (It will be noted that this division is intended to protect the reputation of the institution as much as to aid the student. It will also be evident that (*b*) and (*c*) require the coöperation of technical departments.)

2. *English as training in thinking.*

   a. Rigorous drill in exposition, especially in definition and analysis.

   b. Briefing and writing of argumentative compositions.

   c. Developing the student's constructive imagination.

   (See Professor C. A. Smith's recommendations.)

3. *English as a tool for use in technical work during and after the college course.*

   a. Note taking.

   b. Writing of reports.

   c. Writing of technical papers for student societies.

   d. Writing and criticism of technical articles.

e. Writing of business letters.

f. Oral presentation of technical matter, including both prepared and impromptu speeches.

4. *English as a groundwork for effective expression.*

a. Reading and study of masterpieces of English literature, in order that their literary quality and technical excellence may influence the student's own style.

5. *English as a link between the professional and the human interests of the student.*

a. Reading and writing of essays interpreting the work of the engineer and explaining the larger meaning of his industrial environment.

b. Reading and criticism of contemporary fiction and poetry which express the spirit of the age.

6. *English as a cultural and recreational escape from the monotonous literalism of vocational study.*

a. Literature studied as literature, with emphasis on its æsthetic values.

b. Reading for the sake of enjoyment, diversion, appreciation. (Far from attempting to show the connection between literature and the engineer's vocation, this type of instruction demands that he forget his profession entirely for the time being and lose himself in a totally different atmosphere.)

a. What aims of English teaching, if any, do you omit from the list given on these pages?

b. What aims, if any, do you add to this list?

c. What is the approximate percentage of time allotted to each division?

It is assumed that replies to these questions will be based on conditions as they actually exist, and not on an improved or ideal arrangement toward which a given institution may be working. For example, an instructor may feel—and rightly—that aim No. 1, dealing as it does with elementary English, should be taken for granted as a part of the student's entrance requirements, although, in actual practice, this division may require from ten to twenty per cent. of the total time given to

English. At the same time, the committee wishes to include suggestions for improvement, both in the distribution and in the methods of presenting the various phases of English instruction. In addition, therefore, to the above brief statement of what is being done, you are invited to give a fuller statement of your experience, and an outline of your recommendation on as many as possible of the following subjects, and on kindred topics concerning which you have something to say.

PART II.

(Please use a separate sheet of paper for each topic.)

1. A Well-Balanced Course in English for Engineering Students.
2. Elective Courses in the Engineering College.
3. Oral English in the Engineering College.
4. Making Correct English a Habit.
5. English as Training in Thinking.
6. Developing the Engineering Student's Constructive Imagination, through Instruction in English.
7. Technical Applications of English for Engineering Students.
8. Literary Composition in the Engineering College.
9. English as a Study of the Human Side of the Engineers' Profession.
10. Literature as a Reflection of the Time-Spirit in Science and in Industry.
11. ''Mere Literature'' in the Engineering College.
12. Entrance Requirements in English for Engineering Students.

Realizing the extra labors which most instructors are now performing in connection with the war, the committee will be all the more grateful for as full and specific a discussion of one or more of these topics as you find possible. Kindly forward replies to Part I to reach the chairman not later than May first. The committee will be glad to have an early contribution dealing with some phases of Part II and to receive further suggestions later at your convenience.

Signed,
COMMITTEE.

Complete figures on the referendum in Part I are not available at the time when this manuscript is sent to the printer. The following data from a tabulation of the first twelve reports may be of interest, as suggesting an average proportion of time given to the different aims in the teaching of English to engineering students.

1. *English as a guarantee against illiteracy among college graduates.* (23.3 per cent.)
2. *English as training in thinking.* (25.5 per cent. Omitted by one.)
3. *English as a tool for use in technical work during and after the college course.* (23.3 per cent.)
4. *English as a groundwork for effective expression.* (10 per cent. Omitted by three.)
5. *English as a link between the professional and the human interests of the student.* (11.6 per cent.)
6. *English as a cultural and recreational escape from the monotonous literalism of vocational study.* (5 per cent. Omitted by six.)

An interesting addition to No. 6 made by one institution is a *cultural course in general information.* This course, the material of which in a number of other colleges is treated under No. 2, is outlined as follows:

Exposition of an idea: Popular government.
Criticism of the permanent peace program.
Emancipation of women.
The meaning of Christianity.
Democracy and education.
The meaning of "Social Justice."
Evolution.
The idea of progress.
Ethics.
Culture.

This is one of several suggestions that the course in English shall acquaint the student with a definite body of non-technical information and shall stimulate his thinking on political, economic, social, æsthetic, and ethical subjects. Indeed, the most conspicuous modification of the ''standard'' course in English just now is in this direction. The theory underlying the change seems to be, first, that along with his technical studies the student should acquire a maturity of understanding in the larger human interests outside his special field; and second, that direct encouragement is needed in order to develop a proper appreciation of these problems. The responsibility and the opportunity of presenting this material falls to the instructor in English, partly because it belongs to no one else, and partly, also, because he is in the best position to arouse interest in human issues and to measure student reactions to them. Thought-provoking material of this kind commends itself especially to the teacher of composition, since it induces natural and spontaneous writing.

Most of the specific data gathered by the committee this year will doubtless be chiefly interesting to teachers of English. The committee hopes to present in a forthcoming report a digest of concrete recommendations which will be directly useful in the teaching of English to engineering students. For technical men in general, the questions of aims, methods, and emphasis outlined in the first part of the questionnaire will, it is believed, prove more interesting and more suitable for discussion at a meeting of the Society.

Respectfully submitted,

C. W. PARK, *Chairman*, Univ. of Cincinnati.
FRANK AYDELOTTE, Mass. Inst. of Technology.
CHARLES ALPHONSO SMITH, Annapolis Naval Acad.
C. F. PARK, Mass. Inst. of Technology.
J. R. NELSON, Univ. of Michigan.
PHILIP B. MCDONALD, Univ. of Colorado.

REPORT OF COMMITTEE NO. 14, ECONOMICS.

The Committee on Economics has had no meetings, having found it more feasible to consider the matters assigned to it by means of correspondence. Owing to the press of other duties, Professor R. H. Fernald found it impracticable to serve on the committee, tendering his resignation immediately after his appointment, and no one was appointed to fill his place.

The Society's instructions to the committee were, "To continue the work of the previous committee." The previous committee collected certain statistics concerning the present status of economics courses in engineering schools and recommended that the succeeding committee "prepare a definite scope and content of courses" based on the following topics:

1. A preliminary study in commercial geography and industrial history.
2. Fundamental course in the principles of economics.
3. Application of these principles to engineering.
4. Lessons upon special application in detail engineering work.

The present committee has made a further study of the existing status of economics courses in technical schools, which study is summarized for the three principal branches of engineering in Tables I and II.

From these data, it appears that about half of the technical schools of the country, taking these forty-two prominent ones as typical, require economics of civil engineering students, and two thirds require it of mechanical and electrical engineering students. Twelve credit hours required of all students is the maximum, and that amount is required at only one institution. A three-credit-hour course seems to be the prevailing custom. Economics is elective or optional in most of those institutions in the above group with zero hours indicated as required, and in a few instances it may be offered for more than the number of required hours. As to the nature of the course, it appears that general principles of economics prevails.

TABLE I.

CHARACTER OF COURSES IN ECONOMICS REQUIRED IN FORTY-TWO LEADING TECHNICAL SCHOOLS.

Nature of Course.	Schools in which Course is Required.					
	Civil.		Mechanical.		Electrical.	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
General economics	21	50	21	50	21	50
Political science	2	4	3	6	3	7
Sociology	1	2	1	2	1	2
Industrial history	1	2	1	2	1	2
Business and finance	2	4	4	9	5	12
Special engineering economics	3	7	5	12	3	7
No course required	18	43	13	31	14	33

TABLE II.

NUMBER CREDIT HOURS REQUIRED IN ECONOMICS COURSE.

Credit Hours Required.			Number of Schools with this Requirement.
CE.	ME.	EE.	
12	12	12	1
0	9	6	1
6	6	6	3
5	5	5	3
4	4	4	1
3	3	3	8
2	2	2	6

In previous discussions of the subject assigned to this committee, a misapprehension has arisen apparently from lack of definition of terms, and particularly from the confusion of two distinct ideas, which are, indeed, the essence of the matter under discussion, namely, ''*economics*'' and ''*economy of construction.*'' The habit of some writers of putting these two subjects together under the term ''economics'' leads to a lack of clarity of purpose. The committee understands the term economics to mean ''The science of wealth'' and to deal with matters pertaining to the consumption, production, exchange and distribution of the world's wealth as a more or less abstract social science. Economy of construction, on the other hand, should cover those principles of design and construction which accomplish desired results with the minimum expenditure of money, all factors being considered, and is founded primarily upon unit costs, maintenance and life of structures and cost of operation. There does not appear any sufficient reason why these two matters which are so essentially distinct in character should be grouped together in their administration. The four topics presented by the previous committee and mentioned above include two, the first and second, that fall under the term *economics,* the other two pertain more particularly to *economy of construction,* and the present committee has so grouped them.

From the information at hand and after as complete an interchange of views as the limitations of correspondence would permit, the present committee has attempted to formulate recommendations concerning (*a*) the amount of time to be devoted to economics, (*b*) the nature of the course and (*c*) the mode of administration.

The committee recommends that an outline course on economics but no more be required of all engineering students. Engineering has chiefly an economic aspect, that is, it has to do with the production, exchange and distribution of wealth, and the student should become familiar with those general factors which are the framework of society's economic organization and should be led to see how engineering operations are related to them. He should understand that an engineer possesses a training that has economic value and that he will be able to "market his wares" only as he comprehends the economic and commercial organization of society from both the theoretical and the practical viewpoints.

As to the proper amount of time to be devoted to economics in engineering courses, the committee, after considering the factors which it believes should control the arrangement of college curricula as well as taking into account the prevailing practice, recommends that the amount of time devoted to the formal study of economics be not more than three semester credit hours. The committee is of the opinion that this amount of time will give the student a sufficient outline of the scope, character and limitations of the subject, while, on the other hand, more than that time cannot be devoted to the subject advantageously for the following reasons. Economics is not an ''exact science'' even with a liberal interpretation of that term, and for that reason largely, engineering students accustomed to studying mathematics, physics, chemistry, mechanics, etc., fail to get the economist's point of view and mode of reasoning and consequently derive very little benefit from an extensive study of economics as a disciplinary exercise. In other words, most of the fundamental propositions of economics are not capable of rigorous and irrefragable demonstration, consequently an extended study of the subject as an exercise in logic may tend toward confusion for the technical student, who is accustomed to less equivocal modes of thinking. The fundamentals of the subject that can be learned in a three-hour course as so much information are sufficient to form a skeleton or framework to which the student can refer his subsequent general reading of a related character. Moreover, owing to the immaturity of the average student's business experience, he has little background for a study of commerce, and for this reason, also, a more extensive study of economics is not considered profitable for engineering students.

With regard to the character of the course, the committee recommends that the subject-matter be similar to the treatment in any standard text on ''economics'' or ''political economy,'' with frequent illustrations from the actual facts of commercial geography and industrial history, with perhaps a few special lectures on these latter subjects near the close of the course, with a view to calling attention to their more prominent features. Not infrequently time in the lecture room or class room is not utilized to the best advantage because trivial and inconsequential illustrations are employed when illuminating illustrations are available from commercial geography and industrial history, and it is urged that advantage be taken of such whenever possible.

Special subjects in the economics group, such as accounting, labor problems, public and corporation finance, taxation, money and banking, and others, while possessing much value as information courses, do not seem to deserve a place in the engineering curriculum owing to the already crowded condition of the latter and also because an intelligent technical graduate can read books on any of these subjects understandingly without the aid of an instructor.

It is further recommended that matters pertaining to *economy of construction* be taught in connection with the separate courses to which they are related, the instruction being adapted to the nature of the particular subject under consideration, rather than offer a separate course in economy of construction with a view to making it cover its various phases. However, special lectures and assignments on the economy of construction should be given from time to time. It is believed that aside from a few elementary mathematical relationships between fixed charges, maintenance and operation, and annual costs, the principles involved are not sufficiently general in their application to warrant a separate course in the present crowded condition of the curriculum.

The committee finally recommends that special attention be given to the mode of administering the course in economics for engineering students. In many institutions there seems to be an apathy on the part of the latter with regard to this subject, due perhaps to one or more of several reasons, such as: the sentiment that it is a liberal arts subject and therefore of no value to an engineer; it is not directly applicable in problems of design or construction; economics not being an "exact science" is so different from the student's usual mode of thought that he finds himself in a strange realm; due perhaps to this last condition, there may arise at times a lack of sympathy between the instructor and the student. Whatever may be the cause, this apathetic attitude should be carefully guarded against.

The committee is of the opinion that the subject of economics should be taught to technical students by a professor of economics having a broad education and experience in corporation business. Neither an immature instructor on the one hand nor a preoccupied head of a department on the other should attempt to instruct engineering students, but a man to whom the subject is alive and possesses a vital connection with the commercial world should be placed in charge, otherwise the natural interest of the student will be stifled.

The problem method of instruction has much to commend it as a method of teaching engineering students, due chiefly to the usual mode of preparing their lessons, viz.: by reading a text and solving problems based on the principles expounded therein. A few such problems assigned daily with written solutions prepared in detail required would add interest as well as value to the course.

Summarizing, the committee recommends that a three-semester-credit-hour course in general principles of economics be required of all engineering students, such course to constitute the entire formal study of this subject in four-year courses; that *economy of construction* be taught in conjunction with the separate courses in design and construction, and that special attention be given to the mode of instruction with a view to accomplishing the most definite results possible in the time allotted to the subject.

Respectfully submitted,

A. B. McDaniel,
W. G. Raymond,
G. F. Swain,
C. C. Williams,
Chairman.

REPORT OF COMMITTEE NUMBER 15, COMMITTEE ON CIVIL ENGINEERING.

Assigned subject "Methods and Details of Teaching Structural Designs."

The committee has planned for a progress report this year and a formal one in 1919. The progress report consists of four papers, prepared by members of the committee as follows:

1. The *objects* of the structural courses.
2. The *subject matter* necessary to carry out these objects.
3. The *manner of presentation* of the subject matter.
4. The *training of instructors* to carry this out in an effective manner.

Three of these papers are published in this issue of the BULLETIN with the hope that the discussion which will follow at the Convention and in future issues of the BULLETIN may serve as a basis for a later report.

Submitted by

A. H. FULLER, *Chairman,*
H. J. BURT,
C. T. MORRIS,
W. C. HUNTINGTON,
J. HAMMOND SMITH.

THE OBJECTS OF THE STRUCTURAL COURSES.

BY HENRY J. BURT,

Structural Engineer.

In this land, where education is a public function, the welfare of the commonwealth has first claim to consideration in the objects to be attained. The selfish interests of the student must be subordinate. If success be considered works accomplished rather than financial gain, the interest of the state and the interest of the student may be considered identical. The man should be trained to be a constructor, rather than a contractor; to be an economist of materials and labor rather than an economist of money; to conserve or make useful material resources rather than to consume them. These considerations are very general but should be in mind while specifying the training to be given in structural engineering.

Structural engineering is here considered as a part of the broad profession of civil engineering. Although its importance is growing rapidly in relation to the other branches of civil engineering, it has not yet become recognized as a distinct and separate profession. It follows that the structural courses must be a part of any complete curriculum of civil engineering. So far as the writer is informed, it is so recognized in all engineering colleges.

A broad definition of structural engineering makes it include all static structures whose designs are based on scientific principles and mathematical calculations. It involves the relation of load to strength, or stress to strain. There is practically no engineering design that does not involve the principles and calculations of structural engineering. This being so, it is evident that structural courses should form an important part in the study of civil engineering.

The proportion of the time which should be devoted to this subject is not easy to determine. Perhaps the minimum that should be considered is that required for the study of mechanics of materials, physical properties of materials, and static stresses. At the other extreme would be the time required in curricula when electives are allowed and the student chooses subjects in structural design as his major courses.

The purpose of most students in engineering is to prepare for the practice of the profession as a means of livelihood. If left to their own guidance, they would likely select the subjects that promise the earliest results, *i. e.,* get them into remunerative employment at the earliest practicable date.

This would lead to the study of the practice of engineering rather than the science on which that practice is based. In a few years the man would find that he was practising the art of engineering rather than the science; that he had become an artisan rather than a professional engineer.

Such a result as described above does not represent the best development of the student, so he must be guided into a better channel. He is entitled to such training that he can secure employment in engineering work, but he is not entitled, nor is it to his interest, to be so trained that he can secure an advanced position in practical work, but be lacking in the foundations from which he can build a professional rather than a craftsman's career.

In spite of good resolutions made at the time of graduation, this natural tendency is to neglect scientific studies. Very few young engineers after graduation give any time to advancing their knowledge of the theory of engineering, except when forced to do so by the problems confronting them. The less they know of scientific principles, the less likely they are to pursue the study of them after leaving school.

Recognizing the inability of the student to be his own guide during college days, and recognizing his tendency to neglect scientific study after graduation, it devolves on the teachers not only to prescribe the studies to be pursued during the college period, but to so train the student that he will continue in a progressive channel—all this to the end of securing the best ultimate result rather than early but limited success.

The foregoing discussion indicates the desired preponderance of training in the science of design. The purpose of this training is twofold: (*a*) To store in the brain the fundamental principles involved so that they will always be ready for reference. This should be done as thoroughly as the implanting of numbers and letters is done in childhood. (*b*) To develop in the mind the powers of analysis, synthesis, observation, imagination and logic, so that the man will always be a student.

Some work in the art of design is necessary to illustrate the principles involved. It should be done more with this purpose than for the purpose of training a craftsman. The latter feature cannot be wholly disregarded for the man must be equipped with enough practical skill to make him useful and enable him to start in the practice of his profession. But he must depend on his experience after leaving college to assemble in his storehouse the information, and to acquire by practice the skill that will ultimately make him a success in his profession.

SUBJECT MATTER.

BY C. T. MORRIS,

Professor of Structural Engineering, The Ohio State University.

In the opinion of the writer, the major portion of the work in a civil engineering course should be of a fundamental character and required of all civil engineering students.

As a person grows older, the necessity for a broad training in cultural subjects as well as the sciences impresses itself upon one. It should be the purpose of a college course to prepare one to meet the responsibilities of life and the business world, and to make, above all, good citizens who can take places of responsibility and leadership in their communities.

In the usual four-year course there remains little time for specialization after the necessary fundamental sciences have been taken, and it is the opinion of the writer that the great majority of college students in their third and fourth years are not mature enough to intelligently select the special branch of civil engineering into which it is best for them to enter. In fact the great majority of graduates embrace the most promising opportunity which presents itself after graduation and usually remain in the special line upon which they first enter. This fact makes it desirable that all should have the foundation upon which may be based a career in either municipal, railway or structural engineering.

Some selection of studies should be allowed in the fourth year of the course, but probably not to exceed 8 to 12 credit hours.

The fundamentals required of all civil engineering students should include the following:

Language, including English,
Mathematics through the calculus,
Chemistry,
Physics,
Engineering drawing, including descriptive geometry,
Surveying—land, railroad, and topographic.
Geology,
Mechanics—statics, strength of materials, kinetics and hydraulics,
Materials of engineering, including testing of materials,
Steam, hydraulic and electric power, general course,
Astronomy and geodesy,
Sanitary engineering and water supply, general course,
Timber construction,
Roads and pavements,
Stresses and structural design, general course,
Concrete and reinforced concrete,
Masonry construction,
Economics of engineering,
Contracts and specifications.

After these courses have been given the necessary space in a four-year course, it is seen that very little time remains for specialization, not more than 8 to 12 hours at the most. In these 8 to 12 hours, the student should be allowed to elect any one of several groups of studies along the lines of municipal and sanitary engineering, railroad engineering, or structural engineering.

The structural engineering group should include courses in advanced bridge design, tall building construction, and the principles governing the calculation of statically indeterminate stresses and secondary stresses.

Even if more time than is here indicated is devoted to structural engineering, an effort should *not* be made to turn out finished draftsmen or detailers. The technique of draftsmanship and detailing can be acquired in a few months in any structural drafting room, and if the fundamentals of the subject have been mastered in college the ultimate value of the man will be greatly increased.

Neatness and accuracy, in English, arithmetic, and drawing should be insisted upon during the entire course. Frequent individual problems should be assigned and the solutions required handed in in ink. These should be carefully checked over and errors indicated, as half of the instructional value of the problem is lost if the work is not done independently and the mistakes found and corrected.

Inspection trips to structures in the vicinity should be made and examples of good and bad design pointed out. In this way, as in no other, can methods of construction be taught. The average student has very little conception of these matters and even photographs will not adequately serve. Also if possible, an inspection trip should be made to a plant where structural steel work is fabricated, in order to give the student a general idea of the methods of manufacture.

And finally, the fact should be impressed upon the student that when he graduates he has only completed the first stage of his education. His study and investigation along his chosen line should continue if he expects to keep pace with, and take advantage of the opportunities for advancement which will be constantly offered to those qualified for them.

A brief outline of the structural work given in the civil engineering course at the Ohio State University will serve to illustrate the content of the subjects listed above.

Stresses and Structural Design is required of all civil engineering students except those specializing in municipal and sanitary work. Four recitations or lectures per week for two semesters are required.

In teaching this course an effort is made to review briefly the principles of mechanics because it has been found that no matter how thorough the training in mechanics has been, the students require some review in order to intelligently grasp the application to structural design. After this brief review of the principles of statics, the graphic and algebraic solution of the stresses in roof and bridge trusses is taken up, followed by the method of coefficients for trusses with parallel chords. The analysis of the stresses in trusses with subpanels and with curved chords is also taken up. Then the wheel load analysis is given for trusses with parallel chords and the methods of calculating stresses up to wind and centrifugal force for bridges with curved track are given. This finishes the course in stresses but it is seldom that all of it can be completed before the end of the first semester and usually part of it has to be taken up in the first part of the senior year.

The work in bridge design commences with the design of beams and plate girders, followed by the design of the main members of truss bridges. Then the design of the details is taken up, commencing with riveting, net sections, pins, etc.

Throughout the course individual problems are given and required to be handed in in ink. Considerable time has been required in developing these individual class problems but I believe that the results fully justify the effort. No matter how conscientious the student may be, if all of the members of the class are working with the same problem, a comparison of results is bound to occur and some of the men will not obtain the benefit that is obtained by the solution of individual problems.

We do not spend a great deal of time in the drafting room in this course as I believe that with the thorough training in engineering drawing which our students receive in the engineering drawing department they can take up the technique of structural drafting in the drafting room in a very short time and that their time in college is much more profitably spent in getting the fundamentals of design. The records of the graduates of this department I believe will bear out this view.

For those specializing in municipal and sanitary engineering a three-hour course for one semester is given covering both stresses and design of simple roof trusses.

Concrete and Reinforced Concrete is required of all civil engineers and is given in two parts, a two-hour laboratory course in testing cements, aggregates and concrete mixtures, and a three-hour recitation and lecture course in reinforced-concrete design. In this latter course the methods of design of beams, slabs, tee beams, columns, etc., are taken up and a full-size reinforced-concrete beam is tested and extensometer measurements made so that the relations between the actual deformations and the theoretical are determined.

A thorough course in *Masonry Construction* is given to all civil engineers covering two semesters, four hours and three hours per week respectively. In this course is taken up a thorough study of the materials and the design of piers, abutments, foundations, retaining walls and similar masonry structures.

Two courses are offered which are optional and are taken by those wishing to specialize in structural work. These are *Advanced Bridge Design* and *Tall Buildings.*

The course in *Advanced Bridges* takes up the subject of cantilevers, swing bridges and arches. In this course an effort is made to give the fundamentals regarding the calculation of stresses in these types of bridges and also some work in design. Work in both steel and reinforced concrete arches is taken up.

The course in *Tall Buildings* commences with the design of the floor construction including the various types of reinforced-concrete and tile floors and then proceeds to the design of the floor beams and floor girders. After this follows the design of columns for (both central and eccentric loading) the wind bracing (both with and without diagonals), and finally the footings and foundations.

REPORT OF COMMITTEE NO. 15.

TRAINING OF INSTRUCTORS IN STRUCTURAL ENGINEERING.

BY J. HAMMOND SMITH,

Professor of Civil Engineering, University of Pittsburgh.

The essential qualifications of a good teacher may be summed up under the following headings.

1. He must have a commanding bearing in relation to his classes.
2. He must know his subjects thoroughly.
3. He must be able to inspire and lead his students.
4. He must be able to judge his students fairly.
5. He must maintain a congenial relation in general with his associates on the teaching staff.

The teacher must be in full command in his classroom, at all sessions, whether they be lectures, recitations or design periods The first requisite of any instructor is to maintain proper decorum. This may be often done tactfully—by substituting recitations and quizzes for what would ordinarily be explanatory lectures. If lectures do not receive proper attention from the class as exhibited by decorum and attention, they should be discontinued or given less frequently or reduced in scope, and a method more compelling laid down before the student; viz., recitations consisting of blackboard work with explanations before the class, or oral and written quizzes. The efforts of many lecturers are largely wasted because many minds in the class are wandering from the subject being presented. Even the best students will tire under a continuous lecture system. The author prefers to use a system of combined lectures, recitations and quizzes, and doubtless there are many others in the engineering teachers profession who are using practically the same methods. First the instructor should assign the lesson for the following period with any brief explanatory remarks which may seem necessary. Then he should explain clearly, and without too much haste, the essential points in the day's lesson. If one-hour periods are used he may lecture for fifteen minutes, or if the scope of the subject for the hour is unusually large or complicated he may take the whole period and omit lecturing in the following period. He should review the subject in the text shortly before presenting it to his students, so that he can explain the essential points in such a way as to augment the students' book knowledge of the subject, instead of delivering the subject in a different manner or order and thus confusing the student. Usually the class should be encouraged to ask questions at the end of the instructor's lecture. These questions are generally a very good measure of the students' knowledge of the subject, although most students are not cognizant of this means of bringing them out in their true stature. It is highly important that the instructor resort to good diagrams or illustrations as an aid in making his lectures clear. If blackboard illustrations are used, they should be prepared, if possible, before the lecture. Great caution should be exercised by the lecturer in guarding against confusion, by presenting the lectures in the wrong order or by broadening the subject unduly, or reaching over into the following lesson unintentionally. This caution also applies when answering students' questions, as many students will ask questions beyond the lesson or not vitally related to the subject. Many teachers, just the same as many writers, do not appreciate the fact that a superfluity of words only serves to hide the basic essentials of the subject.

Following the lecture part of the period, a part of the class should be assigned problems to be worked out and later explained at the blackboard. The remaining part of the class should be given one general problem to be worked on paper at their seats, and the instructor should circulate among these students to make sure that they are using the proper methods of solution. It is a wise plan to use individual and original problems very frequently in addition to the problems found in the text.

The preliminary calculations in elementary design may be carried on to the best advantage by lectures with blackboard work to direct and check the students, who are at their seats or tables with notebooks and references. The calculations should be sufficiently full to permit the student to begin drafting with practically all required data in his notebook. If possible the preliminary design should just precede the work on the drawing board. Brief lectures may be interspersed through the drafting periods as would seem necessary to clear up points which were not definitely decided in the preliminary design.

An instructor in structural engineering should be a man who has had considerable experience in structural plants in addition to his course in engineering. He should be highly interested in his subject and constantly progressing, by means of laboratory research work and outside practice in the profession.

The heads of the various departments should keep in close touch with their instructors, especially with their new instructors. The latter should receive careful instruction on methods of teaching and scope of work to be covered.

The instructor should use tact and judgment in gaining the confidence of his students. He can then encourage greater effort by requiring of the student all he can accomplish, but no more. If a student is overloaded he is likely to lose confidence in himself, because he is unable to work out anything to his satisfaction. And it is satisfaction which promotes interest.

REPORT OF COMMITTEE NO. 21, MILITARY ENGINEERING.

The first conflicts between man and man were nothing more than the conflicts between two animals who used the weapons with which nature had endowed them. Physical or brute strength were the dominant characteristics, intelligence and skill were secondary, the prize of victory was existence and the cost of defeat was death.

As civilization developed and grew, physical strength became less and less a factor with the development of arms and appliances which put the small man on a par with the large, and gave the victory to the mentally rather than the physically great, so that to-day the mentally trained or educated is the superior to the moral, physically strong.

This has been called an engineer's war and the tremendous call for engineers has been well answered by our engineering schools.

A letter received from the Chief of Engineers of the United States Army indicates that the present courses are as a general thing well fitted for the service to be rendered in war.

The special education and training required has been outlined by the War Department in an official Bulletin from the Chief of Staff, Vol. I, No. 4, and in General Orders No. 49 from the War Department establishing the Reserve Officers' Training Corps. Copies may be obtained from Washington.

Course of training for engineers' units of the Senior Division is as follows:

1. Military Art.

   Three hours a week (counting 14 units).

   (*a*) Practical. Weight 10.

   Physical drill (Manual of Physical Training—Koehler).

   Infantry drill (U. S. Infantry Drill Regulations), to include the School of the Soldier, Squad, and Company, close and extended order.

Practical military engineering—laying out and constructing trenches, obstacles, and revetments (Part V, Engineer Field Manual, and 584–595, Infantry Drill Regulations). Use sand table when outdoor work is impracticable.

(*b*) Theoretical. Weight 4.

Military organization (Tables of Organization).

Service of Security (Field Service Regulations).

Personal hygiene (lectures).

Part V, Engineer Field Manual (including latest addendum); omit mining and demolitions.

2. Military Art.

Three hours a week (counting 14 units).

(*a*) Practical. Weight 10.

Physical drill (Manual of Physical Training—Koehler).

Infantry drill (U. S. Infantry Drill Regulations), to include School of Battalion and Ceremonies.

First-aid instruction.

Range and gallery practice.

Practical military engineering—military mining and demolitions (Part V, Engineer Field Manual).

(*b*) Theoretical. Weight 4.

Lectures on general military policy as shown by military history of United States and military obligations of citizenship.

Service of Information (Field Service Regulations).

United States Infantry Drill Regulations, to include School of Company.

Camp sanitation for small commands (lecture).

Part V, Engineer Field Manual—military mining and demolitions.

3. Military Art.

Three hours a week (counting 14 units).

(*a*) Practical. Weight 10.

Same as course 2 (*a*) except practical military engineering, which will consist of knots and lashings and improvised military bridges.

(*b*) Theoretical. Weight 4.

United States Infantry Drill Regulations—School of the Battalion.

Small-Arms Firing Regulations, paragraphs 1–134.

Part II, Engineer Field Manual—Bridges.

4. Military Art.

Three hours a week (counting 14 units).

(*a*) Practical. Weight 10.

Same as course 2 (*a*) except practical military engineering which will consist of building military bridges, including floating bridges and instruction in rowing when practicable.

(*b*) Theoretical. Weight 4.

Lectures on recent military history.

Field Service Regulations—patrolling, advance and rear guard and outpost, orders and messages, marches, and camps and camp expedients.

Ponton Manual.

5. Military Art.

Five hours a week (counting 24 units).

(*a*) Practical. Weight 13.

Duties consistent with rank as cadet officers, non-commissioned officers, and instructors in connection with the practical work and exercises of the student taking courses 1 (*a*) and 3 (*a*).

Military reconnaissance and sketching.

(*b*) Theoretical. Weight 11.

Review of Parts II and V, Engineer Field Manual.

Notes on Field Fortification (Army Field Engineer School).

Part I, Engineer Field Manual—Reconnaissance. Weight 8.

Company Administration—general principles (papers and returns). Weight 1.

Two lectures on the History of Military Engineering (Students to submit notes on lecture). Weight 2.

6. Military Art.

Five hours a week (counting 24 units).

(*a*) Practical. Weight 13.

Duties consistent with rank as cadet officers, non-commissioned officers, and instructors in connection with the practical work and exercises of the students taking courses 2 (*a*) and 4 (*a*).

Military reconnaissance and sketching.

(*b*) Theoretical. Weight 11.

Review of military mining and demolitions in Part V, Engineer Field Manual.

Review of Ponton Manual.

Field Service Regulations, paragraphs 354–410, 242–246, and appendix 2. Weight 8.

Elements of international law. Weight 2.

Property accountability and methods of obtaining property (Army Regulations). Weight 1.

7. Military Art.

Five hours a week (counting 24 units).

(*a*) Practical. Weight 13.

Duties consistent with rank as cadet officers, non-commissioned officers, and instructors in connection with the practical work and exercises of the students taking courses 1 (*a*) and 3 (*a*).

Military reconnaissance and sketching.

(*b*) Theoretical. Weight 11.

Field Service Regulations—Article V, Combat.

The use of engineer troops—Official Bulletin No. 4.

Map reading and map maneuvers.

Manual of Courts-Martial.

8. Military Art.

Five hours a week (counting 24 units).

(*a*) Practical. Weight 13.
Same as course 7 (*a*).
(*b*) Theoretical. Weight 11.
Organization and equipment of engineer troops.
Night illumination of battlefield.
Studies in minor tactics (School of the Line, 1915).
Lectures on military history and policy, based on Upton.

The schedule of training prescribes graded courses covering a period of four years, and instruction will be taken up as follows:

BASIC COURSE.

Freshman year, courses 1 and 2 (28 units).
Sophomore year, courses 3 and 4 (28 units).

ADVANCED COURSE.

Junior year, courses 5 and 6 (48 units).
Senior year, courses 7 and 8 (48 units).

COURSE OF TRAINING FOR JUNIOR DIVISION, TOTAL WEIGHT 22 UNITS.

1. Infantry drill regulations (practical and theoretical, to include definitions, general principles, combat and ceremonies).

School of the Soldier..... School of the Squad..... School of the Company... School of the Battalion...	In extended order, combat, and intrenchments.

2. Manual of Interior Guard Duty (practical and theoretical). Duties as sentries; general principles.

3. Physical drills: Calisthenics, bayonet exercises, and combat fencing.

4. Military hygiene: To include principles of personal hygiene, camp sanitation, first aid to the injured, etc.

5. Military policy: A few lectures when in last year at in-

stitution on the military policy of the United States and the military obligation of citizenship.

6. Small-arms firing regulations: Preliminary instruction in rifle firing; sighting position and pointing and aiming drill; indoor and range practice; due attention devoted to fire direction and control and, if possible, some collective fire.

7. Administration and organization: A few lectures on company administration and tables of organization.

8. Map reading: Instruction in reading a contoured map (in connection with 9).

9. Field service regulations: Patrolling advance and rear guards; outposts, by means of the sand table and small map maneuvers; messages and orderly work.

10. Marches and camps: Simple camping expedients.

11. Signaling: Semaphore and flag.

Owing to the wide range of the ages of students in this class of institutions, the majority being too young to follow intelligently a graded course such as is prescribed for the senior division, only the subjects in which proficiency must be attained are laid down. It is impossible to set any fixed number of years for the accomplishment of this programme, and hence each institution should arrange its schedule of instruction so that the cadet upon graduation will be proficient in all of the above subjects.

Should the cadet enter a collegiate institution in which is organized a senior division of the Reserve Officers' Training Corps he will not have to repeat the theoretical work in any of the above subjects, but he will not be excused from any practical work. He will not, however, repeat any work in the school of the soldier or squad if the professor of military science and tactics judges him to be proficient in such schools.

The courses prescribed can be added to in case institutions so desire, but the minimum requirements quoted above must be completed upon graduation.

To those who sign the agreement to take these courses, the

Government makes a certain allowance in both uniform and subsistence.

For those in institutions close to the sea, similar work could probably be done for the Navy.

C. S. SPERRY, JR.,
J. N. BRIDGMAN,
C. J. TILDEN,
H. S. BOARDMAN,
L. S. RANDOLPH, *Chairman.*

AMERICAN UNIVERSITIES AND RUSSIA.

American universities and colleges are doing their part to strengthen the morale of Russian universities, according to a letter recently written to Hon. Robert Lansing, Secretary of State, by P. L. Campbell, secretary of the Emergency Council on Education, which represents the national organizations of American schools, colleges and universities. Dr. Campbell asked the Secretary of State to transmit to the faculties of the universities of Russia the text of a letter prepared by the Emergency Council in order to give sympathy and encouragement to the leading scholars of Russia. The following is the letter prepared by the Emergency Council:

With grave concern we have heard reports of the dangers and difficulties which have beset the universities of Russia. Unprecedented events have worked to disorganize the educational system built up with years of arduous endeavor in your land. As representatives of sister institutions in a country whose whole heart sympathizes with Russia in her danger, we offer to you our sincerest wishes for the unabated continuance of the great work in education which your nation has carried on, and the assurances of our unanimous desire to render all the help in our power. Threatened to-day by a relentless and materialistic military power, the world must unite to keep burning the pure flame of a learning which seeks the salvation of mankind. The ancient friendship of Russia and the United States of America renews itself to-day in the bond which education for a common end has forged between the universities of your land and ours.

(Signed) EMERGENCY COUNCIL ON EDUCATION.

EDITORIALS.

The War Department and Engineering Schools.—With the creation of the Committee on Education and Special Training of the War Department, we have an attempt for the first time in the history of this country to correlate the engineering schools with the direct and important needs of the government service. This experiment, which is being conducted on a very large scale, will demonstrate to the country that institutions of higher learning stand ready to provide that type of education which is needed in order that men may be trained efficiently for service with the government. While engineering schools will in this way contribute materially to the success of the war, they will also reap many benefits. For instance, the injection of new types of instruction into the curriculum, the repetition of courses with a frequency of about eight weeks, etc. Here is an opportunity to make careful studies of educational problems because of the results of modification in methods of teaching which are immediately available. It also provides excellent opportunities for trained teachers to train other teachers and thus themselves to become better trained. The effect of this kind of work on engineering education will without doubt be marked in at least three ways: (1) The modification of the curriculum; (2) modification of the types of instructors employed; (3) some modification in entrance requirements.

How to Study.—In these strenuous times it is interesting to note that at least one prominent engineer is interested in this important subject. A little booklet has recently been issued by Professor George F. Swain which has been widely used in various institutions, especially with freshmen. In one institution, for instance, three class periods have been devoted to the discussion of the contents of the book and each student required to prepare a theme describing his own method of study as compared with those described in the text. This subject is important in connection with the training of soldiers because of the necessity of developing in a large group in a short time some ability to study.

Further Information Regarding the Northwestern Meeting, June 26–29.—It is suggested that as guests arrive at Evanston they go directly to the Lindgren House, the center house in the dormitory group on the North Campus, where arrangements may be made for rooms and meals.

The nearest elevated station is Noyes Street—the campus is two blocks east.

The nearest Chicago and Northwestern station is Davis Street. A convenient way to reach the campus is to walk to Sherman Avenue one block east and take a street car to Noyes Street.

The meetings will be held in Swift Hall of Engineering, a short distance south of the dormitories.

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